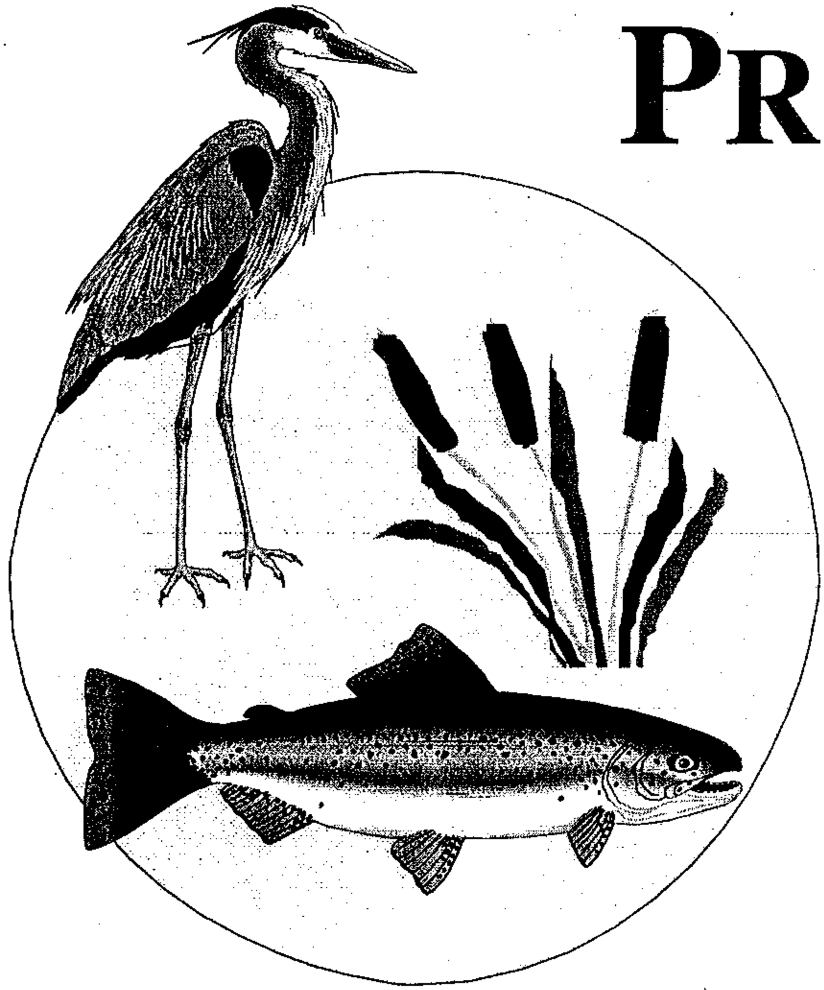
# Ecosystem Restoration Program Plan



**Volume II**

## Ecological Zone Visions

CALFED
BAY-DELTA
PROGRAM

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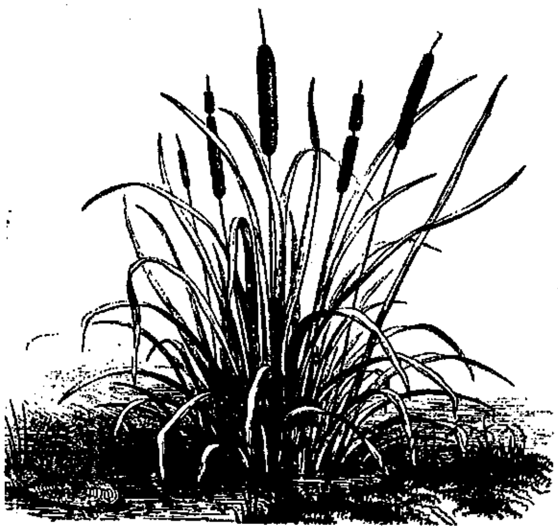


## INTRODUCTION

The Sacramento-San Joaquin River Delta (Delta) is the tidal confluence of the Sacramento and San Joaquin Rivers. Between the upper extent of tidewater (i.e., near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and the confluence of the two rivers near Collinsville is a maze of tidal channels and sloughs known as the Delta. Once a vast tule marsh with an interconnecting maze of sloughs and channels, it is now islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small "channel" islands or shorelines of remaining sloughs and channels.

The Delta is home to many species of native and non-native fish, waterfowl, shorebirds, and wildlife. All anadromous (i.e., migrating between river and ocean) fish of the Central Valley either migrate through the Delta or spawn in, rear in, or are dependent on the Delta for some critical part of their life cycle. Many of the Pacific Flyway's waterfowl and shorebirds pass through or winter in the Delta. Many migratory song birds and raptors migrate through the Delta or depend on it for nesting or wintering habitat. Despite many changes, the Delta remains a productive nursery grounds and migratory route for many species. Four races of chinook salmon, steelhead, green and white sturgeon, striped bass, and American shad migrate through the Delta on their journey between the Pacific Ocean and Central Valley spawning rivers. Native resident fish including delta smelt and splittail spend most of their lives within the Delta. Considerable areas of waterfowl and wildlife habitat occur along the channels and sloughs and within the leveed agricultural lands.

Ecological factors having the greatest influence on Delta fish and wildlife include freshwater inflow from rivers, water quality, water temperature, channel configuration and hydraulics (waterflow), wetlands, riparian vegetation, and diversity of aquatic habitat. Stressors include water diversions, poor water quality, legal and illegal harvest, wave and wake erosion, agricultural practices, conversions of agricultural land to vineyards, urban development and habitat loss, pollution, and introductions of non-native plant and animal species.

## DESCRIPTION OF THE ZONE

The Sacramento-San Joaquin Delta Ecological Zone is defined by the legal boundary of the Sacramento-San Joaquin River Delta (Figure 2). It is divided into four regional ecological units: North Delta Ecological Unit, East Delta Ecological Unit, South Delta Ecological Unit, and Central and West Delta Ecological Unit.

The Sacramento-San Joaquin Delta Ecological Zone is characterized by a mosaic of habitats that support the system's fish and wildlife resources. Instream and surrounding topographic features influence ecological processes and functions and are major determinants of aquatic community potential. Both the quality and quantity of available habitat affect the structure and composition of the Delta's biological communities. Currently, much of the remaining natural habitats consist of small, scattered, and degraded parcels. Other, more common wildlife habitats on agricultural lands are at risk of loss because of levee failures. Important aquatic habitats are severely limited by levees and flood control systems.

Important aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat; vegetated and nonvegetated shallow shoal areas; open-ended sloughs, both large and small; and small dead-end sloughs. The large, open river channels of the Sacramento and San Joaquin Rivers in the central and western Delta are more like the tidal embayments of Suisun Bay to the west of the Delta. Areas with SRA habitat are fragmented and subject to excessive erosion from wind- and boat-generated waves. Shallow shoal areas are small and fragmented and are subject to excessive water velocities and periodic dredging that degrade or scour them.

Remaining channels and sloughs have been modified to become water conveyance "facilities" and flood control features. These modifications resulted in elevated water velocities and loss of structural diversity. The few remaining small dead-end sloughs have lost their SRA habitat, are choked with water hyacinth, and have poor water quality from agricultural and dairy runoff. Reclamation of Delta islands has cut off miles of dead-end sloughs that once drained extensive tidal wetlands and has significantly reduced the amount of land-water interface.

Geographic Information System (GIS) program analysis of 1906 U.S. Geological Survey maps provided estimates of the historical wetted perimeter in Delta sloughs and channels and tidal emergent wetlands. The 1906 maps were the earliest available, and even then many Delta levees had already been constructed. These perimeter calculations were compared to similar data from GIS mapping by Pacific Meridian for the California Department of Fish and Game (DFG) using 1993 satellite imagery. That comparison indicated that there have been wetted perimeter reductions in three of the four Delta ecological units since 1906. Wetted perimeter reductions ranged from 25.2% to 44.7%.

**Change in Ratio of Wetted Perimeter**
**1906 to 1993**
(Ratio of water to land acreage)

| Ecological Unit | 1906 | 1993 | Percentage of change |
|---|---|---|---|
| North Delta | 3.4 | 4.5 | +32.3% |
| East Delta | 10.5 | 7.1 | -32.4% |
| South Delta | 11.9 | 8.9 | -25.2% |
| Central and West Delta | 3.8 | 2.1 | -44.7% |

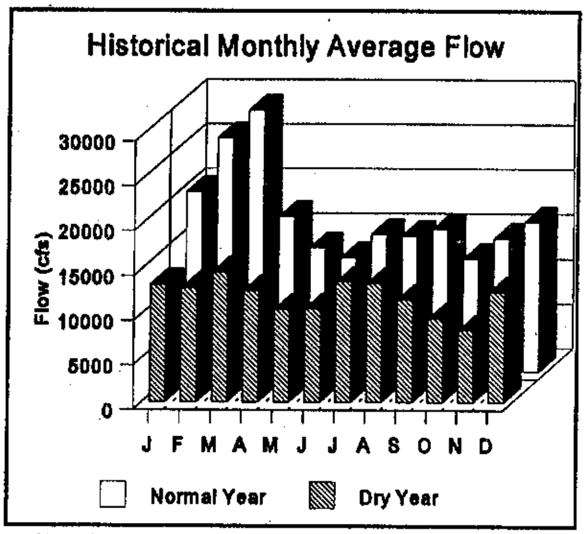
Central Valley water supply and hydroelectric projects have had a large effect on the freshwater flow through the Delta. Spring flows that, before water projects, averaged 20,000 to 40,000 cubic feet per second (cfs) in dry years and 40,000 to 60,000 cfs in normal years have, in recent decades, averaged only 6,000 to 10,000 cfs in dry years and 15,000 to 30,000 cfs in normal years.

In the driest years, spring flows were once 8,000 to 14,000 cfs, while under present conditions they average only 2,500 to 3,000 cfs. In dry and normal years, summer outflow from the Delta has remained in the 4,000- to 8,000-cfs range because water is released from reservoirs to keep salt-water from entering the Delta. Summer inflows that were only 4,000 to 8,000 cfs in dry and normal years now exceed 10,000 cfs as water is released from reservoirs to satisfy demands for water diversions.

Winter flows have fallen from the 15,000- to 60,000-cfs range to the 7,000- to 35,000-cfs range because much runoff from winter rains is now stored in foothill reservoirs. Flows in years with the highest rainfall are relatively unchanged, although short-term peaks are attenuated by flood control storage in the larger foothill reservoirs.

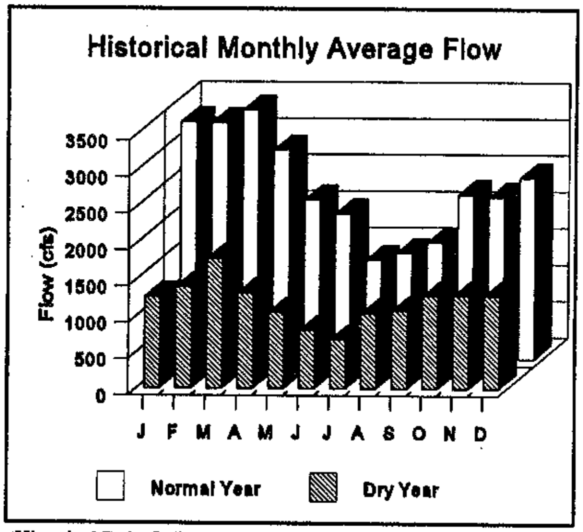
Much of the Delta outflow is made up of Sacramento River flow entering the Delta near Sacramento. Although inflows through the Sacramento River channel reach 60,000 to

80,000 cfs in winter and spring of wet years, inflows are generally less than 30,000 cfs. In the driest years, inflows range from 5,000 to 9,000 cfs through the entire year, while in dry years they range from 8,000 to 15,000 cfs. In wet years, floodflows that average up to 130,000 cfs per month enter the Delta from the Yolo Bypass through Cache Slough.

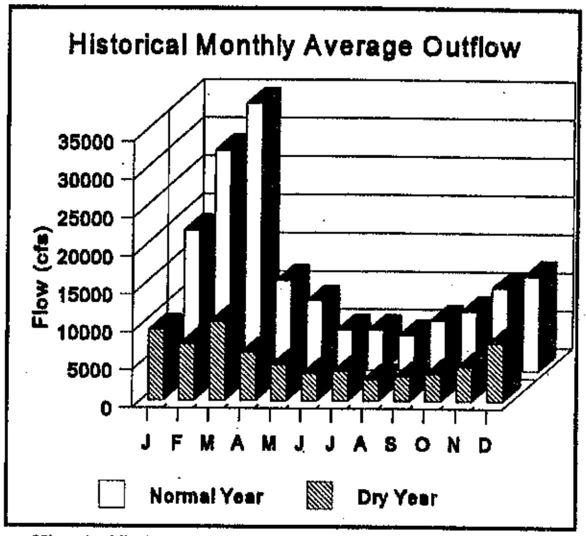



Historical Delta Inflow from Sacramento River Measured at Freeport, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Most of the remaining inflow to the Delta comes from the Mokelumne River and the San Joaquin River. The Mokelumne River contributes only 100

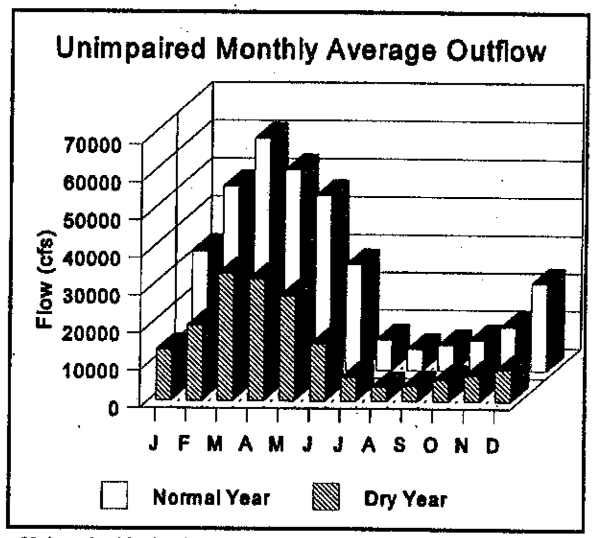



Historical Delta Inflow from San Joaquin River Flow at Vernalis, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)




Historical Delta Outflow for 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

to 300 cfs in dry and normal years. The San Joaquin River flows make up most of the remainder with average monthly flows of 500 to 1,500 cfs in dry years, 1,500 to 3,500 cfs in normal years, and up to 20,000 to 40,000 cfs in wet years.




Unimpaired Delta Outflow Estimated for Period 1972-1992 (Dry year is the 20th percentile; normal year is the 50th percentile or median year.)

Water diversions from the Delta may reduce outflows by as much as 14,000 cfs. Of that total, small Delta agriculture diversions combine to divert up to approximately 3,000 cfs during peak irrigation seasons. State Water Project (SWP) and

Central Valley Project (CVP) pumping plants in the southern Delta can divert up to 11,000 cfs.

Natural floodplains and flood processes are the periodic flooding of the floodplain during peak flow events that would typically occur in late winter and spring of all but the driest years. Land reclamation and levee construction have eliminated much of the natural Delta floodplain, forcing waters to rapidly exit the Delta through confined channels. Only the Yolo Bypass and adjoining leveed islands are periodically flooded to help carry large flows coming down the Sacramento River.

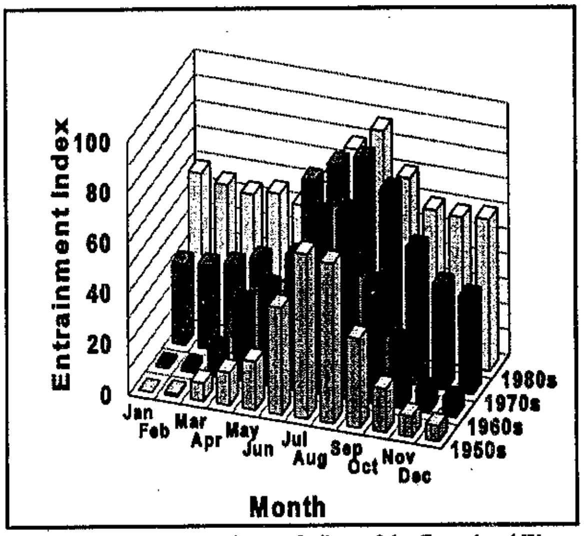
Reductions in spring freshwater flow into the Delta and the loss of riparian vegetative cover have led to slightly increased water temperatures in the Delta. Agricultural and other discharges into the Delta including power plant cooling water have also increased Delta water temperatures. Maintaining water temperatures in the Delta during the transitions in spring and fall is necessary to meet the needs of migrating salmon and steelhead passing through the Delta. Reduced March to May inflows and loss of riparian (waterside) and SRA habitat in the Delta have also contributed to higher water temperatures in the Delta.

Changes in Delta channel hydraulics (water flows) began in the mid-19th century with land reclamation that restricted flows to narrow channels of levees. Floodflows that once spilled into a vast floodplain are now confined to narrow channels. These same channels later became conduits for carrying water to water-export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta at Tracy to the Delta-Mendota Canal. That same year, operation of the Delta Cross Channel (DCC) began to allow Sacramento River water to flow through interior Delta channels to the south Delta export facilities at Tracy. South Delta export facilities were increased with the addition of the SWP pumping plant at Byron in the late 1960s. In 1968, the SWP began to transport Delta water through the California Aqueduct to southern California.

Existing hydraulic conditions inhibit the function of Delta channels as migration corridors and rearing habitat for salmon and other anadromous fish, including steelhead, striped bass, American shad, and white and green sturgeon. Native resident fish such as delta smelt and splittail also depend on natural hydraulic processes, as hydraulic conditions determine physical habitat characteristics and foodweb (all of the food chains) production (i.e., by controlling the residence time of water in Delta channels). Natural hydraulic conditions benefit other resident freshwater and estuarine (river mouth) fish, including longfin smelt, tule perch, threadfin shad, white catfish, largemouth bass, and starry flounder. Low residence time in Delta channels and sloughs decreases biological productivity and habitat value.

Channel hydraulics once were relatively unaltered in the Delta. In November through May, an important period for aquatic species, changes were insignificant in the 1950s and 1960s, as measured using an indicator of hydraulic conditions. However, by the 1980s, there had been a dramatic increase in unhealthy channel hydraulic conditions in locations such as the Central and West Delta.

The historic entrainment index in based on the DeltaMOVE model. This model is a tool to used to evaluate both historic and project impacts based on hydraulic conditions in the Delta. The




Historic Calculated Entrainment Indices of the Central and West Delta Ecological Unit.

estimated percentage of the spawned population that is entrained at the State and federal facilities provides and indicator of losses during transport to the western Delta and Suisun Bay.

Aquatic foodweb productivity in the Delta has declined over the past several decades and is the subject of ongoing focused research activities. The decline was caused by changes in freshwater inflow, Delta channel hydraulics (i.e., water residence time), water diversions, water quality, and the species composition of aquatic organism communities. Foodweb productivity, beginning at the primary production (i.e., plant cell production) level, is essential to provide enough food to maintain populations of important fish. Primary productivity in the Delta depends on spring flow events in dry and normal years. Spring flows deliver essential nutrients, increase residence time in channels and sloughs, and increase shallow water and wetland habitat.

Along with the loss of tidal marshes in the Delta to land reclamation came the loss of shallow-water aquatic habitats (e.g., small sloughs, ponds). Many native resident and anadromous fish and estuarine invertebrates depend on these habitats. Shallow-water habitats around the Delta provide spawning and rearing habitat for many native resident Delta fishes. They also provide important rearing and migratory habitat for many Central Valley chinook salmon and steelhead. Tidal perennial aquatic habitat benefits native waterfowl, wading and shorebirds, and wildlife, as well as native plants that depend on such habitat.

Lakes and ponds support simple invertebrate communities, riparian habitat, and wintering waterfowl. Examples of nontidal perennial aquatic habitats include the Stone Lakes in the North Delta Ecological Unit near Sacramento and the "blow out ponds", or ponds remaining after levee breaks on islands such as Venice Island and Webb Tract. Most ponds also support introduced species such as the bullfrog and largemouth bass, which reduce the value of these ponds to special-status species such as the red-legged frog. Introduced species also reduce the habitat's value as brood water for nesting waterfowl. Such habitat within the Delta also benefits waterfowl, as well as many plant and wildlife species, including many rare or declining special status species.

After more than 100 years of land reclamation activities in the Delta, many linear miles of natural sloughs have been lost. Sloughs are important spawning and rearing areas for many native Delta fish species, as well as waterfowl and wildlife. Of those natural sloughs that remain, most have been severely degraded by dredging, levee confinement, loss of riparian vegetation, high water flow, infestation of water hyacinth, and poor water quality (i.e., many have agricultural drains).

**Species-Habitat Associations**

| Species | *Habitats* |
|---|---|
| Swainson's hawk | *Riparian/Agricultural* |
| Clapper rail | *Tidal emergent wetland* |
| Black rail | *Emergent wetland* |
| Sandhill crane | *Seasonal aquatic and wetland, agricultural, and grassland* |
| Riparian brush rabbit | *Contiguous riparian woodland* |
| Shore and wading birds | *Aquatic and wetland, seasonal aquatic, and agricultural* |
| Upland game birds | *Agricultural, riparian, and upland* |
| Waterfowl | *Tidal perennial aquatic, seasonal aquatic, riparian, agricultural, and wetland* |
| Neotropical songbirds | *Riparian* |
| Delta smelt | *Shallow water, sloughs, bays* |
| Splittail | *Marsh, floodplain, sloughs* |
| Striped bass | *Shallow water, sloughs* |

Shoals are simple underwater islands or shallows in otherwise deeper channels of the Delta. Channel islands and shoals provide valuable fish and wildlife habitat within the confined reaches of Delta channels. Only "tule islands" or "berm islands" contain some original native Delta habitats. These islands are found in Delta channels where the distance between levees is wide enough that past dredging activities left a remnant strip where soils were deposited at an elevation high enough to support tules and cattails. Such islands generally have shallow water and SRA habitats, as well as tidal marsh and riparian habitats. The number and acreage of channel islands has declined over the past several decades from dredging, wave and wake erosion, and levee maintenance.

Tidal marshes, once the most widespread habitat in the Delta, are now restricted to remnant patches. A GIS analysis of 1906 U.S. Geological Survey maps determined the extent of change in tidal emergent wetland since 1906. Extensive losses of emergent wetland habitat in three of the four Delta ecological units have exceeded 87,000 acres from 1906 to 1993. These losses represent only a portion of the changes that have taken place since reclamation began in the mid-nineteenth century.

Nearly two-thirds of reclamation of the Sacramento-San Joaquin Delta Ecological Zone for farmland occurred before 1906 (Thompson 1965). Thirty percent of the lands reclaimed before 1900 were in the North Delta and East Delta Ecological Units, 38% in the South Delta Ecological Unit, and only 2% in the Central and West Delta Ecological Unit. Most of the remaining tidal wetlands lack adjacent upland transition habitat and other attributes of fully functioning tidal wetlands. This was caused by upstream water development, in-Delta export facilities, adjacent levee maintenance practices, agricultural practices, and urban and industrial development.

Emergent wetlands provide important habitat for many species of plants, waterfowl, and wildlife. In addition, wetlands provide an important contribution of plant (dead material) and nutrient recycling to the aquatic foodweb of the Bay-Delta estuary, as well as important habitat to some species of fish and aquatic invertebrates.

Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats such as managed duck clubs in the Delta floodplain. Most of this habitat is located on leveed lands or in floodplain bypasses such as the Yolo Bypass. Such habitats were once very abundant during the winter rainy season or after seasonal flooding of the Delta. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife.

Upland habitats are found mainly on the outer edges of the Delta and consist primarily of grasslands and remnant oak woodland and oak savanna. Of these, perennial grasslands are an important transition habitat for many Delta wildlife species. They are also buffers to protect wetland and riparian habitats. Much of the grassland habitat adjacent to the Delta has been lost to agriculture (e.g., grain, vineyards, and orchards) and development (e.g., home construction, golf courses). Grasslands provide habitat for many Delta plant and animal species.

Riparian habitat, both forest and shrub, is found on the water and land side of levees, berms, berm islands, and in the interior of some Delta islands. This habitat ranges in value from disturbed (i.e., sparse, low value) to relatively undisturbed (i.e., dense, diverse, high value). The highest value

**Acres of Tidal Fresh Emergent Wetland (Marsh)**

| Ecological unit | 1906 | 1993 | Percentage of change |
|---|---|---|---|
| North Delta | 53,660 | 4,640 | -91.3 |
| East Delta | 7,600 | 1,270 | -83.3 |
| South Delta | 470 | 650 | +38.3 |
| Central and West Delta | 37,170 | 5,040 | -86.4 |
| **Total** | **98,900** | **11,600** | **-88.6** |

riparian habitat has a dense and diverse canopy structure with abundant leaf and invertebrate biomass. The canopy and large woody debris in adjacent aquatic habitat provide shaded riverine aquatic habitat on which many important fish and wildlife depend during some portion of the life cycles. The lower value riparian habitat is frequently mowed, disced, or sprayed with herbicides, resulting in a sparse, habitat structure with low diversity.

Riparian habitat is used by more wildlife than any other Delta habitat type. From about 1850 to the turn of the century most of the riparian forests in the Delta were decimated for fuelwood as a result of the gold rush, river navigation, and agricultural clearing. Remnant patches are found on levees, channel islands, and along the margins of the Delta. Riparian habitats and their adjacent shaded riverine aquatic habitat benefit many species of fish and wildlife.

Inland dune scrub habitat is found in the south and west portions of the Delta in areas where wind-blown sand is deposited along margins of the Delta. Inland dune habitat has unique native plant communities including two special-status species. Much of the dune habitat has been lost to industrial and urban development.

Agricultural habitats also support populations of small animals, such as rodents, reptiles, and amphibians, and provide opportunities for foraging raptors. Nonflooded fields and pastures are also habitat for pheasant, quail, and dove. The Delta supports a variety of wintering and breeding raptors. Preferred habitat consists of tall trees for nesting and perching near open agricultural fields that support small rodents and insects for prey. Both pasture land and alfalfa fields support abundant rodent populations.

The Swainson's hawk, a raptor species listed by the State as threatened, breeds and occasionally winters in the Delta. One of the highest breeding densities of Swainson's hawks in the Central Valley is found on the eastern edges of the Delta, primarily along the upland margins in areas adjacent with pastures, alfalfa croplands, and grasslands. The present-day Delta is mostly farmland, occupying over 86% of the dry-land area. The wildlife habitat value of these lands depends on crop types and agricultural practices employed, including flooding and tillage regimes. The farmed "wetlands" of the Delta are important for wintering water birds, including shorebirds, geese, swans, ducks, and sandhill cranes, supporting 10% of all waterfowl wintering in the State.

Water diversions in the Delta divert up to 14,000 cfs of the freshwater inflow to the Delta. Though diversions vary seasonally, relatively high rates can occur in any month. Water diverted from the Delta is used throughout much of the central and southern portion of the State.

With many diversions unscreened or poorly screened great numbers of fish and aquatic invertebrates are exported with the water. In addition to organisms, diversions export a disproportionately large portion of the nutrients and detrital load that drive the Delta foodweb. Losses of fish and invertebrates, and nutrients and organic debris limit the recovery potential of many species of fish. These losses also reduce the potential for improving the productivity of the Bay-Delta aquatic foodweb. Lack of adequate screening and location of water diversions in sensitive areas of the Delta contribute to the loss of important fish and aquatic foodweb organisms.

Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat on levees and shorelines needs improvement to restore the variety of species and ecological functions needed for aquatic and wildlife resources of the Delta.

Dredging and disposal of dredge materials have contributed to the loss and degradation of important aquatic habitat and vegetated berm islands in the Delta.

Over the past several decades, the accidental introduction of many marine and estuarine organisms from the ballast waters of ships from the Far East has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta with further effects up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Another important route for the introduction of invasive species is overland at border crossings.

The numbers of predatory fish have increased at certain locations in the Delta (e.g., Clifton Court Forebay) and losses of some resident and anadromous fish to predation may limit their recovery. Predators may reduce populations of important fish, including chinook salmon, steelhead, and delta smelt.

Large amounts of toxins continue to enter the Delta from municipal, industrial, and agricultural discharges. The toxins have had a demonstrated effect on the health, survival, and reproduction of many important Delta fish and their foodweb organisms. Toxins in the tissues of the fish are also a human health risk to people who eat Delta fish. Continued reductions of toxins from discharges and from releases of toxins from the sediment (e.g., those disturbed by natural forces and dredging) are essential to the restoration program.

The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Harvest of chinook salmon, steelhead, and sturgeon in the Delta may affect recovery of these populations. Harvest enforcement and management help sustain important fish populations from overharvest.

Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitat along Delta channels. High boat speeds and traffic endanger remnant habitat and limit the success of habitat restoration.

The delta smelt population of the Bay-Delta estuary is a federally listed threatened species. It depends on the Delta for spawning and rearing habitat. It lives in fresh and brackish bays and sloughs of the Delta. Delta smelt decline is related to poor habitat conditions during periods of drought. Delta smelt benefit from high freshwater inflow, particularly during the late winter and spring of dry years. Their recovery depends on adequate slough and shallow water habitat, reduced effects of water diversions, and increased productivity of the aquatic foodweb.

The longfin smelt populations of the Bay-Delta lives within the brackish water and saltwater of northern San Francisco Bay and migrates upstream into the Delta to spawn. The decline in the longfin smelt population has coincided with a number of changes in the estuary including: low flows in late winter and spring, reduced freshwater flows through the Delta and into Suisun Bay, water diversion (particularly in drier years), and contaminants.

Like delta smelt, splittail are a native resident species of the Delta and Bay that depend on the Delta for spawning, rearing, and feeding. The Delta splittail population has declined, especially during recent droughts. Splittail depend primarily on shallow water habitats for spawning including shorelines, sloughs, and aquatic habitats associated with wetlands and seasonal floodplains (e.g., the Yolo Bypass in the north Delta). The splittail population will benefit from improved wetland and slough habitat, a more productive aquatic foodweb, and higher late-winter and spring freshwater flows during dry years. Losses to water diversions may also be a limiting factor in their recovery.

White sturgeon and green sturgeon populations in the Central Valley use the Delta for migrating, feeding, and as a nursery area. Populations appear to be stable. Sturgeon benefit from high late-winter and spring freshwater inflow, a productive aquatic foodweb, and slough habitat in the Delta. Legal and illegal harvest and losses to water diversions may be limiting their abundance.

Four runs of chinook salmon use Central Valley waterways. All four runs depend on the Delta during at least a portion of their life cycle. The Delta provides migratory and rearing habitat for salmon in all but the warmest summer months. Tidal perennial marsh habitat and adjoining sloughs and aquatic habitats in the Delta are important fry rearing habitat.

Many populations of chinook salmon have declined in recent decades. The decline was caused by a combination of ocean, river, and Delta factors. Reductions in freshwater flow through the Delta and increases in water diversions have led to declines in salmon populations. Improving late-winter and spring freshwater flows through the Delta and reducing losses to diversions are essential to the recovery of salmon. Chinook salmon also benefit from lower water temperatures in spring and fall, adequate aquatic habitats, and high foodweb productivity. Many juvenile chinook salmon are lost to water diversions and predators.

The striped bass population of San Francisco Bay and the Sacramento and San Joaquin Rivers depends on the Delta for much of its life cycle. The Delta provides important spawning and rearing habitat for striped bass. Reductions in freshwater flow and increases water diversions have resulted in striped bass population declines over the past several decades. Poor water quality in the Delta may also be limiting the survival of young and adults. Striped bass also benefit from high aquatic foodweb productivity. Loss of tidal perennial aquatic, wetland, and slough habitats may also limit production of striped bass. Many striped bass young are lost in water exported through water diversions. Artificially rearing young striped bass salvaged at the south Delta pumping plant fish facilities or supplementing production with hatchery-reared fish may be necessary to sustain the population under present limiting factors.

American shad is an anadromous fish that spawns in the Sacramento River and its major tributaries. They pass through the Delta on their upstream spawning migration in spring. In the fall, young mitigate through the Delta on their way to the ocean. A portion of the population spawns and rears in the Delta. Though the population appears stable and healthy, low productivity in periods of drought is a concern. American shad production with higher late-winter and spring freshwater flow through the Delta in dry and normal rainfall years. Improved aquatic foodweb production and lower relative export rates at water diversions will benefit American Shad.

Many native and non-native fish species are residents of the Delta. Resident fish populations, like delta smelt and splittail, will benefit from improved aquatic habitats and foodweb production. Many native fish species have declined gradually over the past century from loss of habitat and introductions of non-native fishes. More recently, native resident species have further declined from changes in freshwater flow, water diversions, poor water quality, and further non-native species introductions and habitat degradation. For many of these species, improvements in their native habitats such as sloughs and tidal marshes, is essential to their restoration. Native residents will also benefit from more natural freshwater flow patterns, improved water quality, and reduced losses to water diversions.

Marine fishes include many species that are abundant and important ecologically in the Bay and coastal waters. Two ecologically important species are the Pacific herring and northern anchovy, whose young are important in the foodweb as prey of salmon, sturgeon, and striped bass, as well as other fish and waterfowl such as cormorants and terns. Pacific herring, Dungeness crab, and Bay shrimp also support commercial fisheries. Starry flounder contribute to the local Bay-Delta sport fishery. The Bay and Delta are essential spawning and nursery areas for many marine fish and invertebrates found in the Bay and coastal waters.

Factors that affect the survival and production of marine fish and invertebrates in the Bay-Delta include Delta outflow, water diversions, foodweb productivity, availability and quality of shallow water and wetland habitats, and water quality.

Improvements in production and survival of marine and estuarine fishes in the Bay and Delta will provide ancillary benefits to important estuarine, anadromous, and resident fishes of the Bay-Delta.

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

The western spadefoot and California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

Once possibly abundant in the Delta, the giant garter snake and western pond turtle are now rare there. Improvements in wetland, riparian, and grassland habitats around the margins of the Delta could greatly benefit these species.

Once abundant in the Delta, Swainson's hawk is now rare. Improvements in agricultural and riparian habitat will aid in the recovery of the Swainson's hawk.

A long-term decline in emergent wetlands has reduced the population of California black rail in the Delta. Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail.

The population of greater sandhill crane in the Central Valley has declined over the past century with the loss of permanent and seasonally flooded wetlands. Improvements in seasonally flooded wetlands and agricultural habitats should help toward recovery of the greater sandhill crane population.

Herons, egrets, and other shorebirds and wading birds breed and winter throughout the Central Valley and the Delta. Their populations depend on aquatic and wetland habitats. Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats.

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

Many species of waterfowl overwinter in the Delta and depend on high-quality foraging habitat to replenish their energy reserves. They depend on wetland, riparian, aquatic, and agricultural habitats. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats.

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

Neotropical bird species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

The Lange's metalmark and the delta green ground beetle, both federally listed endangered species, and the valley elderberry longhorn beetle (VELB), a federally listed threatened species, are respectively associated with inland dune, vernal pool, and riparian habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

Once abundant in riparian woodlands of the Delta, yellow-billed cuckoo have declined with the loss of riparian habitat there. The yellow-billed cuckoo will benefit from improvements in habitat that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta.

## DESCRIPTIONS OF ECOLOGICAL UNITS

### NORTH DELTA ECOLOGICAL UNIT

The North Delta Ecological Unit (Figure 3) is bounded on the south and east by the Sacramento River. Notable features are the Yolo Bypass, the Sacramento deep water channel, the Cache Slough complex, the Sacramento River and adjoining sloughs, the Snodgrass Slough and Stone Lakes complex, and the Delta Cross Channel (DCC), which links the Sacramento River with the forks of

**North Delta Ecological Unit Habitat Acreage**

| Habitat | *Acres* |
|---|---|
| Riparian scrub | *1,350* |
| Riparian woodland | *1,602* |
| Fresh emergent wetland (marsh) | *4,640* |
| Seasonal wetland | *4,640* |
| **Total** | ***12,232*** |

the lower Mokelumne River. Land elevations generally range from 5 feet below to 10 feet above mean sea level.

The size of the unit is approximately 235,000 acres. As with the Delta's other units, the primary land use is agriculture with over 60% or 141,000 acres in field crops, orchards, and vineyards. Approximately 5% of the unit consists of riparian, oak woodland, freshwater marsh, and seasonal wetland. (See tables in this section.) Much of the permanent and seasonal wetland habitat is found in the Yolo Bypass, Cosumnes River Preserve, and Stone Lakes area.

**North Delta Ecological Unit Land Use**

| Land use | *Acres* |
|---|---|
| Non-flooded Ag | *118,011* |
| Flooded Ag | *14,528* |
| Orchard | *2,832* |
| Vines | *5,805* |
| Total cultivated | *141,176* |
| Grass | *42,194* |
| Other | *52,480* |
| **Total** | ***235,850*** |

Hydraulic processes in the North Delta Ecological Unit are influenced by tides, upstream water releases, weather, channel diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and natural marsh successional processes. Tidal action and floodwater discharges from the rivers and Yolo Bypass transport nutrients and organic carbon into aquatic habitats of the Delta and San Francisco Bay.

Hydraulic processes have been modified in the North Delta Ecological Unit since the 1890s. Reductions in flow from the Mokelumne River began in the early 1890s with diversions by the Woodbridge Irrigation District. Further diversion began with the completion of the Mokelumne River Aqueduct in the 1930s. Additional agricultural diversions from the river were developed in the 1960s when the present level of diversions from the Mokelumne River was reached. The construction of the Yolo Bypass significantly altered hydraulic patterns during above normal and wet water years. The DCC gates began operation in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Unit and away from the mainstem Sacramento River below Walnut Grove.

Hydraulic patterns have been further modified by the significant export pumping beginning in 1951 for the CVP and in 1968 for the SWP. The Barker Slough pumping plant at the east end of Lindsey Slough in the Cache Slough complex was completed in 1988; it exports water directly from the North Delta Ecological Unit to the North Bay Aqueduct.

Current hydraulic conditions in the North Delta Ecological Unit affect the ability of this ecological unit to support channels with suitable residence times and natural net flows; to provide adequate transport flows to the lower estuary; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of many small unscreened diversions in the North Delta Ecological Unit are undocumented.

## EAST DELTA ECOLOGICAL UNIT

The East Delta Ecological Unit (Figure 4) is bounded on the northwest by the Sacramento River; on the northeast by the Mokelumne and Cosumnes Rivers; and on the south by Highway 12, the South Fork of the Mokelumne River, White and Disappointment Sloughs, and the San Joaquin River. Notable features are Georgiana Slough, the DCC, the Cosumnes River Preserve, and the Woodbridge Ecological Reserve. Land elevations generally range from 10 feet below to 10 feet above mean sea level with the western half of the unit ranging from 10 feet below to 5 feet below mean sea level and the eastern half ranging from 5 feet below to 10 feet above mean sea level.

This ecological unit consists of over 100,000 acres. It contains both forks of the Mokelumne River, the Cosumnes River, three dead-end sloughs (Beaver, Hog, and Sycamore), and important waterfowl wintering and sandhill crane foraging and roosting areas. As with the Delta's other units, the primary land use is agriculture with over 68% in field crops, orchards, and vineyards. (See table in this section for land use acreage.)

Less than 5% of the east Delta consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitat. Much of the riparian and permanent and seasonal wetland habitat is found along the Cosumnes and Mokelumne Rivers and in the White Slough Wildlife Area.

**East Delta Ecological Unit Land Use**

| Land Use | Acres |
|---|---|
| Non-flooded Ag | 58,937 |
| Flooded Ag | 6,054 |
| Orchard | 870 |
| Vines | 2,653 |
| Total cultivated | 68,514 |
| Grass | 10,906 |
| Other | 21,152 |
| **Total** | **100,572** |

Hydraulic processes in the east Delta are influenced by tides, river inflow, weather, channel diversions, and upstream water releases. Unimpeded tidal action into tidal wetlands affects the habitat's sediment and nutrient supplies. These supplies influence the natural marsh successional processes. Tidal outflows transport nutrients and carbon into Bay-Delta aquatic habitats.

Hydraulic processes have been modified in the east Delta since the 1800s. Reductions in flow from the Mokelumne River began in the late 1800s and continued to decline into the 1960s. The DCC gates began operating in 1951 and increased the flow of Sacramento River water into the East Delta Ecological Unit. Hydraulic patterns have been further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the east Delta are unhealthy. These conditions reduce the ability of this ecological unit to provide suitable residence times and more natural net flows, to provide adequate transport flows to the central and west Delta; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

The effects of the many small unscreened diversions in the east Delta are unknown.

### SOUTH DELTA ECOLOGICAL UNIT

The South Delta Ecological Unit (Figure 5) is bounded on the north by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin, Old, and Middle Rivers; Clifton Court Forebay; and the State and federal fish protection and export facilities. Land elevations generally range from 10 feet below to 10 feet above mean sea level. Only about half of the unit is at or slightly higher than sea level.

This ecological unit consists of over 177,000 acres. The primary land use is agriculture with over 60% in field crops, orchards, and vineyards. Less than 2% of this ecological unit consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitat. Much of the riparian and wetland habitat is found in narrow bands along the San Joaquin River and on small channel islands in Old River. (See tables in this section for acreages.)

Hydraulic processes in the south Delta are influenced by tides, river inflow, weather, channel diversions, and water releases from upstream reservoirs. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies. These supplies influence the natural marsh

| South Delta Ecological Unit Land Use | |
|---|---|
| **Land Use** | ***Acres*** |
| Nonflooded Ag | 98,269 |
| Flooded Ag | 1,909 |
| Orchard | 3,668 |
| Vines | 3,466 |
| Total cultivated | 107,312 |
| Grass | 40,483 |
| Other | 29,434 |
| **Total** | 177,229 |

successional processes. Outflows from tidal wetlands transport nutrients and carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the south Delta since the 1800s. Further reduction in flow started in the 1930s with the completion of the Hetch Hetchy Aqueduct from the Tuolumne River. In the early 1940s, construction of Friant Dam began to significantly alter hydraulic patterns, particularly during water years. The South Bay Aqueduct began diversions directly from the South Delta Ecological Unit starting in 1962. Hydraulic patterns were further modified by the significant export pumping near Tracy, which began in 1951 for the CVP and in 1968 near Byron for the SWP.

Current hydraulic conditions in the south Delta are unhealthy and affect the ability of this ecological unit to support channels with suitable residence times and more natural net flows; to provide adequate transport flows to the entrapment zone; and to support high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

While the effects of many small unscreened diversions in the south Delta are undocumented, effects of the two large export facilities on nearly all Delta anadromous and resident fishes have been well described and are very significant (see "Water Diversions Vision" in Volume I: Resource Visions for more details).

| South Delta Ecological Unit Habitat Acreage | |
|---|---|
| **Habitat** | ***Acres*** |
| Riparian scrub | 899 |
| Riparian woodland | 263 |
| Fresh emergent wetland (marsh) | 650 |
| Seasonal wetland | 430 |
| **Total** | 2,242 |

## Central and West Delta Ecological Unit

The Central and West Delta Ecological Unit (Figure 6) is bounded on the west and north by Suisun Bay, the Sacramento River, Highway 12, the South Fork of the Mokelumne River, and White and Disappointment Sloughs; and on the south by the San Joaquin River, Turner Cut, Whiskey Slough, Trapper Slough, Victoria Canal, and Italian Slough. Notable features are the San Joaquin and Sacramento Rivers, Franks Tract, the channel islands in Middle and Old Rivers, and Potato and Disappointment Sloughs. Land elevations generally range from 10 feet below to as deep as 21 feet below mean sea level. This ecological unit consists of over 200,000 acres. It contains most of the mainstem of the San Joaquin River in the Delta. Agricultural uses account for 48% of the area and include field crops, orchards, and vineyards. Approximately 3% of the area consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland. Much of the riparian and wetland habitat is found on the extensive network of small channel islands in Old and Middle Rivers; on White, Potato, and Disappointment Sloughs; along the edges of Big Break and Franks Track; on the Lower Sherman Island Wildlife Area; and on adjacent tide lands on both sides of the Sacramento River channel between Collinsville and Rio Vista, including

Decker Island and adjacent channels. (See the table in this section for habitat acreage.)

| Central and West Delta Ecological Unit Habitat Acreage | |
|---|---|
| **Habitat** | *Acres* |
| Riparian scrub | *1,004* |
| Riparian Woodland | *248* |
| Fresh emergent wetland | *5,040* |
| Seasonal wetland | *544* |
| **Total** | *6,836* |

The central and west Delta contains most of the heavily subsided (sunken) islands in the Delta. Although nearly 98% of this unit was not reclaimed until after 1900, the highly organic soils of this unit have oxidized at an accelerated rate. This has resulted in subsidence (sinking) of 20 to 30 feet in many places. The subsidence has led to serious potential erosion of the levees around the islands and numerous levee breaks in the last several decades.

The central and west Delta has some of the highest levels of wintering waterfowl within the Delta. They use seasonally flooded croplands on the deeper islands in this unit. The California Department of Water Resources is one of the most significant landowners in this unit owning most of Twitchell and Sherman Islands.

Hydraulic processes in the central and west Delta are influenced by tides, river inflow, weather, channel configuration, water diversions, and river inflow. Unimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands to complement natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transport nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydraulic processes have been modified in the central and west Delta since the 1800s. The South Bay Aqueduct began diversions directly from the south Delta starting in 1962. Deliveries to the Contra Costa Canal began in 1962 directly from Rock Slough in the western portion of this unit. Hydraulic patterns were further modified by the significant export pumping, which began in 1951 for the CVP and in 1968 for the SWP.

Current hydraulic conditions in the central and west Delta are unhealthy. The ability of this ecological unit to maintain suitable residence times and provide more natural flows is restricted. These restrictions inhibit adequate transport flows to the entrapment zone and reduce high-quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

In addition to many small unscreened agricultural diversions (e.g., siphons and pumps), electric generating stations divert up to 1,500 cfs of Delta water. The water is diverted at Antioch, along the San Joaquin River channel, for cooling purposes. Some juvenile Delta fish are stressed or killed in the water diverted for plant cooling. Though the amount of heat added to the Delta is small, it is locally measurable. This combined with other heated discharges contributes to significant seasonal warming of Delta waters.

## VISION FOR THE ECOLOGICAL ZONE

The vision for the Sacramento-San Joaquin Delta Ecological Zone is to achieve a healthier ecological system that better provides for the needs of plants, animals, and people using the system. A healthy ecosystem will have more natural freshwater flow and channel hydraulic patterns. A more natural channel configuration with greater amounts of slough and permanent and seasonal wetland habitat will provide more habitat for fish, waterfowl, and wildlife, and improve aquatic foodweb production and water quality. Improvements in riparian vegetation along waterways will reduce heating of the water and provide habitat for fish and wildlife. A healthy Delta ecosystem will lead to improved survival of anadromous fish that depend on the Delta for a portion of their life cycles, including chinook salmon and steelhead, striped bass, white and green sturgeon, and American shad. A healthy Delta will also help toward improving the native resident fish community including delta smelt and splittail, as well as resident wildlife, migratory waterfowl, neotropical birds, and special-status plants and plant communities.

A restored Delta ecosystem will have improved ecological processes and habitats and reduced stressors. Ecological processes that will be improved include freshwater inflow and outflow, Delta hydraulics, channel configuration, water temperature, floodplain processes, and aquatic foodweb productivity. There will be substantial increases in the acreage of tidal emergent wetlands, seasonal and permanent nontidal wetlands, and shallow water, riparian, and tidal slough habitat. Stresses from land use, urban and industrial development, contaminants, land reclamation, water diversions, flood control (i.e., levees and bank protection), non-native plant and animal species, recreational activity (e.g., boating), water conveyance structures, livestock grazing, and agricultural practices will be reduced.

Following restoration, the Delta will be a better fish spawning, rearing, and migration habitat. A healthy Delta will be more effective in nutrient cycling and will increase primary (plant) and secondary (animal) productivity. Productivity will increase through improved freshwater inflow and outflow, longer hydraulic residence time in Delta channels, and an increase in the amount of tidal wetlands. Improved Delta productivity will also improve the productivity of northern San Francisco Bay.

Both the endangered winter-run chinook salmon and the threatened delta smelt will benefit from improved Delta inflow and outflow during the late winter and spring, greater estuary (river mouth) foodweb productivity, riparian and wetland habitat improvements, and improved screening systems at water diversions.

Much of the new fish and wildlife habitats will come from agricultural lands that are either no longer productive or too expensive to maintain (e.g., levee maintenance costs are too high). These lands will be purchased from willing sellers. Productive agricultural lands will continue to be an integral part of the Delta habitat mosaic and will be protected by upgrading channel configurations and levees.

The Delta's levee system will be effectively maintained to reduce the risk of failure. This will also minimize loss of water quality (e.g., saltwater intrusion) and loss of high-value wildlife habitat and agricultural land. Riparian, wetland, and aquatic habitat along the levees will be improved where possible. In those areas where leveed lands can eventually be restored to tidal action, the exterior levees will be maintained until the island interiors are restored to the proper elevations necessary to support the desired habitats.

A basic restoration strategy is to protect and enlarge areas of remaining native habitats and establish the connectivity of these areas. Such areas in the Delta include:

- the Cache Slough complex,
- Stone Lakes,
- the Cosumnes River Preserve in the north Delta, and
- the Sherman Island Wildlife Area in the western Delta.

Benefits to species and habitats will come predominantly through changes to important physical processes. These processes include:

- freshwater flow into and through the Delta
- hydraulic conditions within Delta channels, and
- the channel configuration of the Delta.

Increasing the amount of the floodplain that is inundated by flood waters and tides, and increasing the amount of shallow water and shorelines will increase tidal aquatic, wetland, and riparian habitats. Habitat improvements will be made in concert with floodplain and levee improvements. Levees will be rebuilt and maintained to include shallow water and riparian habitats that not only protect the integrity of the levees, but also provide valuable fish and wildlife habitat. Agricultural lands on Delta islands will be managed to better support waterfowl and wildlife. Tidal sloughs and creeks will be restored to their former health from improved channel hydraulics, water quality, and riparian vegetation, and reductions in non-native aquatic plants (e.g., water hyacinth).

To ensure this recovery, it will be necessary to reduce stressors. Examples of stressors include unscreened or poorly screened diversions, non-native invasive plant species (e.g., water hyacinth), toxic substances, and human disturbance such as erosion of sensitive habitats from boat wakes. In some cases, fish and wildlife may need temporary or even long-term support through artificial habitat construction, reductions in legal and illegal harvest, or artificial reproduction (e.g., hatcheries).

Improvements to restore the health of the estuary need to be made in a way that contribute to the quality of life for Delta fish and wildlife populations, while protecting the region's agricultural economy and preserving landowner property rights. Rebuilt levees will protect valuable agricultural lands and other properties. Improved fish and wildlife populations will benefit recreation. Greater areas of wetlands and riparian habitat will benefit water quality. With restoration, the Delta would provide improved educational and recreational opportunities. The Delta will provide increased public opportunities for wildlife observation, photography, nature study and wildlife interpretation, fishing, hunting, picnicking, and other activities in a manner that is consistent with maintaining the fish and wildlife values of the Delta and protecting adjacent private properties.

Attaining this vision requires extensive efforts in the Delta, and in watersheds above the Delta. For this reason, this Delta vision is closely tied to the visions for the other 13 ecological zones. Important ecological processes such as streamflow are controlled by upstream reservoirs and watersheds to the Delta. Delta habitat and the productivity of that habitat are greatly dependent on physical, chemical, and biological processes upstream of the Delta.

A focus on natural processes may reduce the need for measures that artificially maintain habitat and plant and animal populations (e.g., hatcheries). It may be necessary, however, to artificially sustain habitat, severely inhibit stressors, and increase population abundance until such time when natural ecological processes and functions are restored. This will be particularly true during the recovery period.

## VISIONS FOR ECOLOGICAL UNITS

### NORTH DELTA ECOLOGICAL UNIT

Habitat restoration, fish passage improvement, and floodplain modifications are the primary focus of the restoration program in the North Delta Ecological Unit (Figure 3). Restoring a mosaic of tidal emergent wetland and SRA habitat at the ecological-unit level should provide essential resources for all species, particularly communities or assemblages of species that have declined significantly within the Delta.

Habitat restoration will focus on four areas:

- the Yolo Bypass including shallow agricultural islands at the south end of the bypass (i.e., Prospect, Little Holland, and Liberty)
- tidal sloughs between the Sacramento Ship Channel and the Sacramento River (i.e., Steamboat, Miner, Oxford, and Elk)
- the Stone Lakes-Cosumnes Preserve complex, and
- the main channel of the Sacramento River from Sacramento to Rio Vista.

Seasonal patterns of freshwater inflow from the Sacramento River, Yolo basin (Cache and Putah Creeks), and the Cosumnes and Mokelumne Rivers would be improved. Fish passage problems in the

Yolo Bypass, DCC, Sacramento Ship Channel, and Snodgrass Slough should be resolved. Unscreened diversions in important habitat and migration pathways should be screened. Non-native plants will be controlled.

The vision for the North Delta Ecological Unit focuses heavily on habitat restoration in the major subunits. In the Yolo Bypass, channels should be constructed to connect to channel improvements in the Yolo basin (i.e., connections with Putah and Cache Creeks, the Colusa drain, and the Sacramento River through the Sacramento and Fremont weirs). These channels should be constructed as permanent sloughs along either side of the bypass.

The sloughs will feed permanent tidal wetlands constructed along the bypass and connected with existing wetlands within the Yolo Waterfowl Management Area. The sloughs would provide rearing and migrating habitat for juvenile and adult salmon, and other native fishes. The sloughs would drain into extensive marsh-slough complexes developed in shallow islands (i.e., Liberty, Little Holland, and Prospect) at the lower end of the bypass. These changes, in conjunction with structural improvements to the bypass floodway (e.g., reducing the hydraulic impedance of the railroad causeway paralleling Interstate 80, and removing levees along the lower Sacramento Ship Channel (see below), will retain and possibly increase the flood bearing capacity of the Yolo Bypass.

To the east of the Yolo Bypass, the vision includes some improvements to the Sacramento Ship Channel. Fish passage problems at the gate structure on the Sacramento River at the north end of the ship channel should be resolved by constructing fish passage facilities. Connections between the ship channel and the new island complexes at Liberty, Little Holland, and Prospect Islands would be considered.

The major sloughs to the east between the ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk, should be improved as salmon migration corridors. Riparian habitat would be improved along these sloughs. Setback levees along portions of these sloughs may expand the slough and adjacent marsh complexes. Increases in the hydraulic connections at the northern end of the slough complex on the Sacramento River and at the southern end at Prospect Island would increase tidal and net flows through the complex, which along with habitat improvements, could represent important rearing and migrating habitat improvements for salmon and other anadromous and resident fish.

Along the Sacramento River channel between Sacramento and Rio Vista, restoration is limited to improvements to riparian vegetation along the major federal levees and to protection and possible improvements to retain remaining shallow-water habitat and tule berms along the river sides of the levees. These habitats may be important spawning habitat of delta smelt and other native Delta fishes and important rearing and migratory habitat of juvenile salmon and steelhead.

The vision for the Stone Lakes-Snodgrass Slough-Lower Cosumnes/Mokelumne complex at the northeast side of the North Delta Ecological Unit includes extensive habitat improvements. These improvements will be consistent with increasing the connection of wetlands and riparian woodlands in the Stone Lakes and Cosumnes preserves. Remnant marshes, riparian woodlands, and tidal sloughs along Snodgrass Slough would be protected and improved. Some small units of leveed agricultural lands would be converted to marsh-slough complexes. Flood control levees would be upgraded and riparian and shallow-water habitat improved on the waterside of the levees. Gated connections with appropriate fish passage facilities (and, potentially, screens) would be considered on the Sacramento River at the north end of Snodgrass Slough and Morrison Creek near Hood to provide this portion of the unit with water at a level consistent with pre-levee flows. Water hyacinth infestations would be controlled throughout the complex. All unscreened agricultural diversions located along salmon migratory corridors or spawning habitat of delta smelt would be screened.

Changes in the operation of the DCC would be considered depending on which program alternative is chosen.

### EAST DELTA ECOLOGICAL UNIT

The vision for the East Delta Ecological Unit focuses on restoration of native Delta habitats that will improve spawning, rearing, and migration habitats of native Delta fishes, as well as provide extensive new amounts of wetland, waterfowl, and wildlife habitat. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, especially communities or assemblages of species that are rare within the Delta. Improvements along the south Mokelumne River and adjoining dead-end sloughs on the east edge of the Delta should be the focus of restoration efforts.

The vision for Georgiana Slough and the north Mokelumne River channel is limited to improvements in riparian habitat along the levees. Emphasis would be placed on improving severely degraded riparian habitat along lower Georgiana Slough.

The vision for the east side of the unit along the South Mokelumne River and its adjoining dead-end sloughs (Beaver, Hog, and Sycamore) is extensive restoration of native Delta habitats. Levee setbacks and improvements along the river and sloughs would be accompanied by shallow-water and riparian habitat improvements.

Subsided leveed lands between the sloughs would be converted to floodplain overflow basins. These floodplains would support non-tidal, permanent tule-marsh wetlands, or seasonal agricultural production. After many decades of flooding, marsh growth, and sediment-laden flood overflow, these floodplains could be converted to tidal wetland.

Tidal headwaters of sloughs and adjacent lands would be opened to provide permanent tidal wetland marsh-slough complexes. Conversion of these agricultural lands would also reduce water diversions (i.e., loss of water and juvenile fish). Levee setbacks and a wider floodplain would improve habitat for fish including resident delta smelt and splittail and seasonal migrant salmon and steelhead from the Cosumnes and Mokelumne Rivers.

### SOUTH DELTA ECOLOGICAL UNIT

Habitat restoration, channel and floodplain improvements, hydraulics, and losses at unscreened diversions and water export facilities are the primary focus of the restoration program in the South Delta Ecological Unit. Restoring a mosaic of habitat conditions at a landscape level should provide essential resources for all species, particularly communities or assemblages of species that are rare within the Delta.

The vision for the South Delta Ecological Unit focuses on restoring floodplain habitat along the lower San Joaquin River between Mossdale and Stockton and improving riparian habitat along leveed sloughs throughout the unit. Improving interior slough complexes of the Old and Middle Rivers would depend on which CALFED alternative is chosen for conveyance through the Delta. Minimal improvements would be made under alternatives that use existing Delta channels because these channels would remain major conduits for moving water to the export pumps. Other alternatives would provide more flexibility in the form of improvements in riparian and emergent wetland habitat and channel configurations.

A major focus of the vision in the south Delta will be expansion of the floodway in the lower San Joaquin River floodplain between Mossdale and Stockton. Setback levees and overflow basins offer opportunities to increase the flood-bearing capacity of the existing configuration of the river floodplain, as well as potential for creating significant amounts of native tidal emergent wetlands within the floodplain, regardless of which conveyance alternative is chosen.

Another important focus of the vision is to solve the problems associated with the export of water from the south Delta export facilities of the SWP and CVP near Byron and Tracy, respectively.

Under all three CALFED alternatives, it is imperative that the loss of juvenile anadromous and resident fishes at the two export facilities be reduced as soon as possible. A new fish screen facility would be constructed that would screen all water for both facilities. The screen system would include a state-of-the-art fish collection, handling, and transport system that would reduce fish losses. Some alternatives would further reduce losses of fish from the south Delta by limiting diversions from the south Delta in seasons when fish are most abundant or vulnerable. Fish losses could also be reduced by providing alternative sources of water to south Delta islands, which would otherwise divert water from existing channels.

A screened-gated barrier at the head of Old River would be installed to prevent San Joaquin River water and fish from moving into the southern Delta. The barrier would help ensure that San Joaquin River water and juvenile salmon would have some chance of reaching the western Delta and the San Francisco Bay. Precautions would be taken in the operation of the barrier to not cause increased delta smelt, winter-run chinook salmon, and other fishes movement south into the South Delta and greater losses at south Delta export facilities.

## CENTRAL AND WEST DELTA ECOLOGICAL UNIT

Restoring habitat is the primary focus of the restoration program in the Central and West Delta Ecological Unit. Restoring a mosaic of tidal emergent wetland and SRA habitat on a large scale should provide essential resources for all species dependent on the Delta. Protecting and enhancing levees around all the deeper islands should include major adjacent shoal and shallow-water habitat, as well as riparian and tule-berm (midchannel islands) improvements. Changes in channel hydraulics will protect and improve habitats in specific sloughs. Water conveyance through the Delta should be concentrated in specific channels that should be reinforced for that purpose, and little habitat restoration should be conducted along these channels so as not to encourage residence of juvenile fishes. Portions of deeper islands should be reclaimed where possible for tidal or nontidal marsh habitat. Unscreened diversions in important migration pathways of salmon and delta smelt should be screened or relocated to other channels. The vision for the Central and West Delta Ecological Unit is to restore fresh emergent wetland habitat, shoal and shallow-water aquatic habitat, and adjacent riparian habitat. Along the main channel of the San Joaquin River where levees are being upgraded; wetland, shoal, shallow-water, and adjacent riparian habitat should be improved. Where feasible, new construction should set back levees on portions of islands where the ratio of levee length to protected agricultural acreage is high. This will potentially reduce levee construction and maintenance costs and provide new tidal shallow-water, slough, wetland, and riparian habitat.

These selected islands would be on higher elevation lands to minimize the need for fill; however, some fill would be needed on deeper corners. On such setbacks, levees would initially be maintained while fill was applied and habitats developed. Eventually, the levees would be breached or gated to allow tidal flows into the newly developed habitats. In some cases, entire small islands may be reclaimed, similar to the way in which portions of western Sherman Island in the west Delta were reclaimed for aquatic and marsh habitat. Along the margins of the unit selected levees could be breached or removed to provide areas of tidal wetlands and adjacent grasslands. The amount of new habitat potentially derived from these actions represents as much as 10% of the total acreage in the Central and West Delta Ecological Unit.

Selected tidal channels and sloughs in the Central and West Delta Ecological Unit (e.g., Potato Slough and Disappointment Slough) retain good habitat in the form of midchannel islands, shoreline marshes and riparian woodlands, and shallow waters. These habitats would be protected and improved by restricting channel hydraulics (i.e., forcing tidal and export flows through other channels) and potentially filling deeper waters to create shoal, shallow-water, and marsh habitats.

These habitats would also require active water hyacinth control.

On deeper Delta islands, levees should be upgraded to protect them from catastrophic failure. Portions of or all of some islands would be considered for establishing permanent nontidal wetlands. Approximately 30,000 acres of these islands would be appropriate for consideration of permanent or seasonal wetland development, or combination wildlife habitat and agricultural use. Selected islands may also be appropriate for flood overflow basins or seasonal water storage reservoirs.

Along the west side of the unit in the Highway 4 corridor, there are many opportunities to combine urban, agricultural, and native Delta habitat developments. There are many opportunities for tidal slough and marsh habitat development in this area. Such opportunities would be more valuable if Alternative 3 were chosen, because the channels in this area would convey less water to south Delta pumping plants.

Unscreened diversion along major pathways of salmon and delta smelt would be relocated or screened. Screening systems at Antioch electric power plants would be upgraded to reduce loss of fish to entrainment through or impingement on the fish screens. The extent of screening needs would depend on which program alternative is chosen

## VISIONS FOR ECOLOGICAL PROCESSES

### CENTRAL VALLEY STREAMFLOWS

Much of the fresh water of the State drains the watersheds of the Central Valley through the Delta. A healthy pattern of freshwater inflow into and through the Delta would entail natural late winter and spring flow events especially in dry and normal water-year types. Such flow events would support many ecological processes and functions essential to the health of important Bay-Delta fish populations. Inflow to the Delta is impaired in dry and normal rainfall years from the storage and diversion of natural inflow to the basin watersheds. The need for inflow coincides with the need for natural flows in the mainstem rivers, their tributaries, and San Francisco Bay.

### NATURAL FLOODPLAINS AND FLOOD PROCESSES

Expand the Delta floodplain by setting back or removing portions of the levee. This would enhance floodwater and sediment retention in the Delta and provide direct and indirect benefits to floodplain dependent fish and wildlife. Such floodplain expansion should also help alleviate flooding potential in other areas of the Delta.

### CENTRAL VALLEY STREAM TEMPERATURES

During spring and fall, Delta channels are used by anadromous fish for migrating between rivers and the Pacific Ocean. Untimely high water temperatures stress migrating fish by delaying their movement or causing mortality. Improvements in riparian and SRA habitat along Delta channels would improve water temperatures in small but important increments in these areas during critical fall and spring migrating periods. Higher inflow in late winter and early spring will help delay warming of the Delta channels.

### DELTA CHANNEL HYDRAULICS

Confinement of Delta channels and use of channels to convey water across the Delta has led to reduced productivity and habitat value of Delta channels. Restoration of natural hydraulic conditions in some Delta channels would improve productivity and habitat values.

### BAY-DELTA AQUATIC FOODWEB

The aquatic foodweb of the Delta, which supports important resident and anadromous fish, has been severely impaired. The major foodweb stressors include drought, reductions in freshwater flow, water diversions, introductions of non-native species (e.g., Asiatic clams), and loss of shallow water and wetland habitats. Proposed improvements in spring flows, channel hydraulics, wetland habitats, and floodplain inundation should lead to a healthier and more productive aquatic foodweb. Improved water quality and greater sediment retention in wetland, riparian, and floodplain habitats will also increase foodweb productivity.

## VISIONS FOR HABITATS

### TIDAL PERENNIAL AQUATIC HABITAT

Land reclamation in the Delta has reduced the area of tidal aquatic habitats such as small sloughs, ponds, and embayments in tidal wetlands. Increased tidal wetland acreage and associated aquatic habitats will provide additional valuable fish and waterfowl habitat.

### NONTIDAL PERENNIAL AQUATIC HABITAT

Increasing the area of ponds and lakes on leveed land in the Delta will provide needed habitat for shorebirds, waterfowl, and wildlife.

### DELTA SLOUGHS

Increasing the number, length, and area of dead-end and open-end sloughs in the Delta will benefit native fishes, as well as waterfowl, wildlife, and neotropical songbirds.

### MIDCHANNEL ISLANDS AND SHOALS

Channel islands in the Delta have associated remnant shallow-water, wetland, and riparian habitats that are valuable for fish and wildlife. Maintaining and restoring these islands is important given the lack of such habitat and limited potential for creating new habitat within the Delta channels.

### FRESH EMERGENT WETLAND HABITAT

Restoring tidal and nontidal marshes in the Delta will benefit foodweb productivity and water quality. It will also provide important habitat for fish, waterfowl, and wildlife.

### SEASONAL WETLAND HABITAT

Increased seasonal flooding of leveed lands and flood bypasses will provide important habitat for shorebirds, waterfowl, and raptors, particularly Swainson's hawk, as well as native plants and wildlife. Flooding and draining of seasonal wetlands also contributes to the aquatic foodweb of the Delta and Bay.

### RIPARIAN AND RIVERINE AQUATIC HABITAT

Restoring riparian (waterside) vegetation corridors along levees and associated SRA habitat will benefit many native fish and wildlife species dependent on this type of habitat.

### INLAND DUNE SCRUB

Protecting remaining inland dune scrub habitat will protect special-status wildlife populations.

### PERENNIAL GRASSLANDS

Protecting and improving perennial grassland habitat will benefit special-status wildlife populations, and help protect adjoining wetland habitat.

### AGRICULTURAL LANDS

Improving habitats on and adjacent to agricultural lands in the Delta will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit special-status wildlife such as sandhill cranes.

## Visions for Reducing or Eliminating Stressors

### Water Diversions

Screening, consolidating, reducing, and relocating water diversions will reduce loss of important fish and aquatic foodweb organisms. These actions will also improve Delta outflow and channel hydraulics. Relocating south Delta diversion and rehabilitating fish facilities should greatly reduce the annual losses to these diversions. Improved screening at large Delta power plants should reduce entrainment and impingement losses of many important Delta fish species.

### Levees, Bridges, and Bank Protection

Levee construction and bank protection have led to the loss of riparian, wetland, and shallow-water habitat throughout the Delta. Habitat improvement on levees and shorelines should help restore biodiversity and ecological functions needed for aquatic and wildlife resources of the Delta.

### Dredging and Sediment Disposal

Reducing the loss of and degradation to important aquatic habitat and vegetated berm islands caused by dredging activities would protect, restore, and maintain the health of aquatic resources in and dependent on the Delta.

### Invasive Species

Over the past several decades, the accidental introduction of many marine and estuarine organisms has greatly changed the plankton and benthic (bottom and shore dwelling) invertebrates of the Delta. These organisms come mainly from the ballast waters of ships from the Far East. The introduction of these invasive species has had further ramifications up the foodweb. Further changes can be expected if restrictions are not made on ballast water releases into the San Francisco Bay and Delta. Border inspections and enforcement of regulations regarding ballast water releases should reduce the number of invasions each year to the Delta. Where invasive species have become a serious problem, possible means will be developed to control their distribution and abundance.

### Predation and Competition

The numbers of predatory fish at certain locations in the Delta (e.g., Clifton Court Forebay) are high and contribute to the loss of resident and anadromous fish. Reductions in these local predator concentrations may reduce predation on important fish, including juvenile chinook salmon, steelhead, striped bass, and delta smelt. Predator control would also improve fish salvage at the State Water Project facilities at Clifton Court Forebay.

### Contaminants

Reducing toxin inputs in discharges and from contaminated sediments is essential to maintain water quality. Reduced concentrations in waters entering the Delta should lead to lower concentrations in Delta water and in fish and invertebrate tissues. Fewer health warnings for human consumption of Delta fish and improved foodweb productivity would also be expected.

### Harvest of Fish and Wildlife

The legal and illegal harvest of fish may limit recovery of some populations in the Delta and its watersheds. Increasing enforcement will help reduce illegal harvest of striped bass and sturgeon in the Delta. Increased enforcement should lead to reduced frequency of violations per check by enforcement personnel.

### Disturbance

Boat traffic in the Delta contributes to the erosion of remaining shallow water, riparian, and wetland habitat along Delta channels. Reducing boat speeds and traffic in channels where remnant or restored habitats are susceptible to wave erosion damage would help preserve existing remnant habitat and ensure the success of habitat restoration efforts.

Reduced rates of erosion and loss of shoreline habitats would be expected in areas of reduced disturbance.

## VISIONS FOR SPECIES

### DELTA SMELT

Recovery of the delta smelt population in the Delta will occur through improved Delta inflow, greater foodweb productivity, increased areas and quality of aquatic habitats, and reduced effects of water diversions. Higher production should be apparent in dry and normal water year types in response to improvement in flows, habitats, and foodweb and to reductions in stressors.

### LONGFIN SMELT

The vision for longfin smelt is to improve the population of this species of special concern in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt.

### SPLITTAIL

Recovery of the Delta splittail population will occur through increased flooding of floodplains, higher late-winter Delta inflow, and improved tidal aquatic and wetland habitats. Greater production of young would be expected in dry and normal water year types.

### WHITE STURGEON AND GREEN STURGEON

The vision for white and green sturgeon is to restore population distribution and abundance to historical levels. Restoration of these species would support a sport fishery for white sturgeon, ensure recovery of the green sturgeon population, and contribute to overall species richness and diversity and reduce conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. White and green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food).

### CHINOOK SALMON

Central Valley chinook salmon populations will remain stable or increase with improved late-winter and spring flows through the Delta, increases in wetland and floodplain habitats, lower spring water temperatures, an improved aquatic foodweb, and reduced effects of water diversions. Survival rates through the Delta should increase. Numbers of young salmon rearing in the Delta should increase with improved winter-spring flows and wetland habitats.

### STRIPED BASS

The striped bass population will benefit from increased inflows to the Delta in late winter and spring, an improved aquatic foodweb, and reduced effects of water diversions. Improvements in water quality and reducing summer losses to diversions may be important in the long-term recovery of striped bass. Given the high reproductive capacity of striped bass, improvements in production of young should quickly follow improvements in flow and foodweb and reductions in stressors.

### AMERICAN SHAD

Central Valley American shad populations will benefit from improved spring Delta inflow and an improved Delta aquatic foodweb. Populations would be expected to remain stable or increase. Increases would be expected in dry and normal rainfall years.

### RESIDENT FISH SPECIES

Many native and non-native fish species will benefit from improved aquatic habitats and foodweb. Population abundance indices should remain stable or increase. The distribution of native resident fishes should increase with widespread habitat restoration. The extirpated Sacramento perch could be restored to new habitats in the Delta.

### MARINE/ESTUARINE FISHES AND LARGE INVERTEBRATES

The vision for marine/estuarine fishes is to restore populations to levels that existed in the early 1980s through restoration of habitat and aquatic foodweb, and improvements in winter-spring Delta outflow. A major focus of recovery efforts should be on enhancement of freshwater outflow in late winter and spring of dry and normal water-year types. Natural Delta outflows in dry and normal water-year types have been reduced particularly in late winter and spring. Such flows are coincident with the occurrence and productivity of marine/estuarine fish and large invertebrates in the upper Bay and Delta.

### BAY-DELTA FOODWEB ORGANISMS

The vision for the Bay-Delta aquatic foodweb organisms is to restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system.

### WESTERN SPADEFOOT AND CALIFORNIA TIGER SALAMANDER

The vision for the western spadefoot and the California tiger salamander is to assist in the recovery of these species in the Bay-Delta. Achieving this vision will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta. Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot and California tiger salamander. Restoration of aquatic, seasonal wetland, and floodplain habitats in the Sacramento-San Joaquin Delta Ecological Zone will help recover this species by increasing habitat quality and area.

### CALIFORNIA RED-LEGGED FROG

The vision for the California red-legged frog is to assist in the recovery of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Zone will help in the recovery of this species by increasing habitat quality and area.

### GIANT GARTER SNAKE AND WESTERN POND TURTLE

The vision for the giant garter snake and western pond turtle is to assist in their recovery in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake and western pond turtle. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Zone will help in the recovery of these species by increasing habitat quality and area.

### SWAINSON'S HAWK

Improvements in riparian and agricultural wildlife habitats will aid in the recovery of the Swainson's hawk. Increased abundance and possibly some nesting would be expected in the Delta as a result of improved habitat.

### CALIFORNIA BLACK RAIL

Restoring emergent wetlands in the Delta should aid in the recovery of the California black rail. Population abundance and distribution should increase in the Delta.

### GREATER SANDHILL CRANE

Improvements in seasonally flooded wetlands and agricultural habitats should help toward recovery of the greater sandhill crane population. The population should remain stable or increase with improvements in habitat.

### SHOREBIRDS AND WADING BIRDS

Shorebirds and wading birds will benefit from restoration of wetland, riparian, aquatic, and agricultural habitats. The extent of seasonal use of the Delta by these birds should increase.

### RIPARIAN BRUSH RABBIT

The vision for the riparian brush rabbit is to assist in the recovery of this State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Unit of the Sacramento-San Joaquin Delta Ecological Zone and the East San Joaquin Basin Ecological Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding.

### WATERFOWL

Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Delta and possibly increases in some populations would be expected.

### UPLAND GAME

The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. Protecting and restoring existing and additional suitable grassland, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats, and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta.

### NEOTROPICAL MIGRATORY BIRDS

The vision for the neotropical migratory bird guild is to maintain healthy populations of neotropical migratory birds through restoring habitats on which they depend. Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitat will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors.

### LANGE'S METALMARK, DELTA GREEN GROUND BEETLE, AND VALLEY ELDERBERRY LONGHORN BEETLE

The vision for the Lange's metalmark, the delta green ground beetle, and VELB is to assist in maintaining the existing Lange's metalmark population and by maintaining its abundance, and to assist in the recovery of the delta green ground beetle and VELB by increasing their populations and abundance through habitat restoration.

### WESTERN YELLOW-BILLED CUCKOO

There is no recent occurrence information for the yellow-billed cuckoo in the Delta. However, the cuckoo would become reestablished in the Delta and will benefit from improvements in riparian habitat. Improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Delta. Their occurrence in the Delta should increase.

## INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Delta will involve a long-term commitment with short-term and long-term elements. Short-term elements include features that can and need to be implemented as quickly as possible either because of a long-standing need or a pressing opportunity. Plan elements where need, priority, technical and engineering feasibility, or cost effectiveness are questionable would be long-term. However, even long-term elements would in most cases benefit from short-term pilot studies that would address need, feasibility, science, and cost effectiveness.

Changes in freshwater inflow patterns to the Delta is a long-standing need; however, without developed supplies, the prescribed spring flows may not be possible in all year types. In the short-term, efforts would be made to provide the flows with available CVP water supplies in Shasta, Folsom, and New Melones Reservoirs using water prescribed by the Central Valley Project Improvement Act (§3406 b2 water) and additional water purchased from willing sellers (CVPIA §3406 b3 or CALFED purchased water). The effectiveness of water dedicated for such purposes would be maximized through use of tools such as water transfers. In the long term, additional environmental water supplies may be needed to meet all flow needs.

Reducing stressors would also have short- and long-term elements. Funding would be available to relocate or screen small unscreened diversions throughout the Delta on a priority basis. Large diversions such as those at the south Delta pumping plants and at the Antioch electric power plants would require further research and testing regarding the technical design and feasibility before they could be cost-effectively screened. Other stressors, such as reducing the erosion effects of boat wakes, can be implemented on an experimental basis to determine potential effectiveness before expanding to full-scale implementation. Increasing enforcement efforts to reduce illegal harvest can be implemented in the short-term as cost and benefits are readily defined.

Habitat restoration measures can also be implemented on a pilot scale to develop design criteria and evaluate technical feasibility, priority, and cost-effectiveness. Habitat restoration on an experimental scale can begin immediately on public lands. Purchase of land or conservation easements of private lands will require a more long-term effort. Cooperative efforts with public and private landowners may be implemented in the short term. Other long-term efforts would include those that take many years to develop such as riparian forests.

Related programs in this ecological zone include the CVPIA and Anadromous Fisheries Restoration Program, the SB 34 levee subvention program, Central Valley Habitat Joint Venture, the Riparian Habitat Joint Venture (a multiagency cooperative effort), Ducks Unlimited's Valley Care program, the Nature Conservancy's Cosumnes River and Jepson Prairie Preserves, the USFWS's Stone Lakes Refuge, the DFG's Yolo Basin Wildlife Area, East Bay Park's Big Break and Little Franks Tract recreation areas, and outreach programs that compensate private landowners who improve wildlife management of their lands. The U.S. Army Corps of Engineer's program to mitigate for habitat losses from levee protection in the Delta should coordinate closely with the restoration program.

Much of the infrastructure to implement the vision for the Delta now exists. Existing programs could implement many of the restoration actions outlined in this vision. In areas where cooperative agency and stakeholder efforts do not now exist, such organizations can be developed to help implement the program. Cooperative efforts where agencies have formed partnerships to restore valuable aquatic, wetland, and riparian habitat in the east Delta would be supported and used as a model for other similar efforts (e.g., the Cosumnes River Preserve, with the Nature Conservancy and Ducks Unlimited). Other examples include the establishment of wildlife refuges at Stone Lakes and the Yolo Bypass, each with multiple partners and commitments. The California Department of Water Resources, DFG, and the U.S. Fish and Wildlife Service (USFWS) own considerable properties in the Delta (e.g., West Sherman Island Wildlife Area), which with funding support can be restored or upgraded to fit the vision. The Interagency Ecological Program (IEP) is an established research and monitoring unit that, with support, can accomplish the expanded evaluation and monitoring needs.

### CENTRAL VALLEY PROJECT IMPROVEMENT ACT

Restoring and maintaining ecological processes and functions in the Delta Ecological Zone will augment other important ongoing and future restoration efforts for the zone. With the CVPIA program the Anadromous Fish Restoration Program of the USFWS's (USFWS 1997) has a goal to double the natural production of anadromous fish in the system over the average production during 1967 through 1991. CVPIA authorized the dedication and management of 800,000 af of CVP yield annually for the purpose of implementing the fish, wildlife, and habitat restoration purposes and measures that include water purchased for inflow to and outflow from the Delta.

### CENTRAL VALLEY HABITAT JOINT VENTURE

The targets for the Central Valley Habitat Joint Venture are included in this vision. The Riparian Habitat Joint Venture seeks to protect and restore connectivity of the remaining riparian habitat. The SB-34 program seeks to improve the reliability of the Delta's levee system. This objective is consistent with the vision of reducing the risk of levee failures, which would adversely impact the terrestrial values currently provided by the lands protected by the Delta's levees.

### SAN JOAQUIN COUNTY HABITAT CONSERVATION PLAN

The San Joaquin County Habitat Conservation Plan is nearing completion and describes mechanisms for offsetting past and future impacts associated with land use changes. The habitat conservation plan outlines an approach for acquiring lands using preservation criteria.

## LINKAGE TO OTHER ECOLOGICAL ZONES

Realizing the vision in this ecological zone depends in part on achieving the targets in the Sacramento River, Eastside Delta Tributaries, Yolo basin, and San Joaquin River Ecological Zones. Achieving targets in the Suisun Marsh/North San Francisco Bay Ecological Zone should be pursued in combination with the Delta to restore important rearing habitat, reduce the introduction of contaminants, and control the introduction of non-native aquatic species. Meeting the flow needs for the Sacramento, Feather, Yuba, American, Mokelumne River, Stanislaus, Tuolumne, and Merced Rivers is essential to the Delta freshwater inflow needs. Aquatic, riparian, and wetland corridors in the Yolo and Eastside Delta Tributaries Ecological Zones are also directly linked and integral to habitat corridors in the Delta.

# Implementation Objectives, Targets, and Programmatic Actions

Targets developed for the Sacramento-San Joaquin Delta Ecological Zone can be classified by their reliability in contributing to attainment of the implementation objectives. The target classification system used in the following section is as follows:

| Class | Description |
|---|---|
| ◆ | Target for which additional research, demonstration, and evaluation is needed to determine feasibility or ecosystem response. |
| ◆◆ | Target which will be implemented in stages with the appropriate monitoring to judge benefit and success. |
| ◆◆◆ | Target that has sufficient certainty of success to justify full implementation in accordance with adaptive management, program priority setting, and phased implementation. |

## Ecological Processes

### Central Valley Streamflows

**Implementation objective:** Restore basic hydraulic conditions to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife, and plant populations.

**General Target:** The general target is to more closely approach the natural (unimpaired) seasonal Delta outflow pattern that:

- transports sediments,
- stimulates the estuary foodweb,
- provides for up and downstream fish passage,
- contributes to riparian vegetation succession,
- transports larval fish to the entrapment zone,
- maintains the entrapment zone and natural salinity gradient, supports favorable striped bass spawning conditions, and
- provides adequate attraction and migrating flows for salmon, steelhead, American shad, white and green sturgeon, striped bass, splittail, delta smelt, and longfin smelt.

Besides seasonal peak flows, low and varying flows are also essential elements of the natural Delta outflow pattern to which native plant and animal species have adapted. Specific targets for different flow pattern attributes may vary with the different storage and conveyance alternatives being considered in the CALFED Program.

**Target 1:** Provide a March outflow that occurs from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal water years, and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (◆◆).

**Programmatic Action 1a:** Prescribed outflows in March should be met by the cumulative flows of prescribed flows for the Sacramento, Feather, Yuba, and American Rivers. Assurances must be obtained (e.g., to limit Delta diversions) that these prescribed flows will be allowed to contribute to Delta outflow. A portion of the inflow would be from base (minimum) flows from the east Delta tributaries and the San Joaquin River and its tributaries.

**Target 2:** Provide a late-April to early May outflow that emulates the spring inflow from the San Joaquin River. The outflow should be at least 20,000 cfs for 10 days in dry years, 30,000 cfs in below normal years, and 40,000 cfs in above normal years. These flows would be achieved through base flows from the Sacramento River and flow events from the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced Rivers (◆◆).

**PROGRAMMATIC ACTION 2A:** Prescribed outflows in late April and early May should be met by the cumulative prescribed flows from the Stanislaus, Tuolumne, and Merced Rivers (see East San Joaquin Basin Ecological Zone), and Mokelumne and Calaveras Rivers (see Eastside Delta Tributaries Ecological Zone). It will be necessary to obtain assurances that these prescribed flows be allowed to contribute to Delta outflow. The flow event would be made up of:

- base flows from the Sacramento River,
- Sacramento River tributaries,
- the Cosumnes River,
- Mokelumne, Calaveras, and San Joaquin tributary pulsed flows prescribed under the May 1995 Water Quality Control Plan, and
- supplemental flows.

**TARGET 3:** Provide a fall or early winter outflow that approximates the first "winter" rain through the Delta (◆◆).

**PROGRAMMATIC ACTION 3A:** Allow the first "significant" fall/winter natural flow into the Delta (most likely either from rainfall or from unimpaired flows from tributaries and lower watersheds below storage reservoirs or from flows recommended by DFG and the Anadromous Fish Restoration Program [AFRP]) to pass through the Delta to the San Francisco Bay by limiting water diversions for up to 10 days. (No supplementary release of stored water from reservoirs would be required above that required to meet flows prescribed by DFG and AFRP.)

**TARGET 4:** Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (U.S. Fish and Wildlife Service 1995) (◆).

**PROGRAMMATIC ACTION 4A:** Supplement flows in May of all but critical years as needed from Shasta, Oroville, and Folsom Reservoirs to maintain an inflow of 13,000 cfs to the Delta.

*RATIONALE: Changing the seasonal pattern of freshwater flows into and through the Delta will help restore the Delta's ecosystem processes and functions. This ecosystem restoration is fundamental to the health of aquatic, wetland, and riparian resources.*

*Providing Delta outflow at the prescribed level in dry and normal years in March will provide the following benefits:*

- *improve survival of juvenile chinook salmon rearing in and passing downstream through the Delta,*
- *provide attraction flows to adult winter and spring run chinook salmon, steelhead, striped bass, white and green sturgeon, splittail, and American shad migrating upstream through the Delta to spawning grounds in the Sacramento River and its tributaries,*
- *provide attraction flows for longfin and delta smelt moving upstream within the Delta to spawn in the Delta,*
- *provide downstream passage flows for steelhead, splittail, longfin smelt, and delta smelt to move through the Delta to the San Francisco Bay,*
- *help maintain lower water temperatures further into the spring to benefit adult and juvenile salmon, steelhead, longfin smelt, delta smelt, and splittail,*
- *stimulate the foodweb in the Delta and Bay,*
- *reduce potential effects of toxins released into Delta waters,*
- *promote growth of riparian vegetation along Delta waterways, and*
- *reduce loss of eggs, larvae, and juvenile fish into south Delta water diversions.*

*Supplementing an existing prescription for late April-early May pulse flow through the Delta from the San Joaquin River will assist juvenile San Joaquin chinook salmon and steelhead moving* *through the Delta to the Bay. The added flow will also help transport Delta and San Joaquin plankton and nutrients that have built up during the spring to the western Delta and Suisun Bay where they will stimulate the spring foodweb on which many of the important fish species living in the Delta depend. In addition, this flow will provide many of the same benefits described above for the March flow event. The flow event would be provided by supplementing the prescribed pulse flow in the 1995 Water Quality Control Plan with additional waters purchased from willing sellers on the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers.*

*Restoring the natural first "fall" flow through the Delta will provide the following benefits:*

- *support spring-run and other chinook salmon, steelhead, and American shad juveniles migrating from the mainstem rivers and tributaries in passing through the Delta to the Bay,*
- *provide attraction flows for adult fall-run and late-fall run chinook salmon, splittail, longfin smelt, delta smelt, and steelhead migrating upstream into or through the Delta, and*
- *reduce losses of migrating juvenile fish in south Delta pumping plants.*

*Maintaining in May a minimum inflow of 13,000 cfs from the Sacramento River will help maintain survival and transport of striped bass eggs and larvae from the Sacramento River above Sacramento into the Delta. This flow will also benefit remaining downstream migrating juvenile chinook salmon and steelhead from the Sacramento River and its tributaries, as well as upstream migrating winter and spring run chinook salmon, white and green sturgeon, and American shad. Supplemental average monthly storage releases of up to 2,500 cfs for 30 days (150,000 total acre-feet) may be necessary in dry years to meet this requirement. In normal and wet years, flows would generally exceed 13,000 cfs.*

*Providing for larger flows during the seasons with when those flows occurred historically, particularly in normal or dry years, will help restore important ecological processes and functions that create and maintain habitat in the Delta. Delta channel maintenance, sediment and nutrient transport, and introduction of plant debris are some examples of processes improved by flow events. Spring flow events in dry and normal years will help sustain riparian and wetland vegetation.*

## NATURAL FLOODPLAIN AND FLOOD PROCESSES

**IMPLEMENTATION OBJECTIVE:** Modify channel and basin configurations to improve floodplain function along rivers and streams in the Sacramento-San Joaquin basin.

**TARGET 1:** Expand the floodplain area in the North, East, South, and Central and West Delta Ecological Units by putting approximately 10% of leveed lands into the active floodplain of the Delta (◆◆).

**PROGRAMMATIC ACTION 1A:** Convert leveed lands to tidal wetland/slough complexes in the North Delta Ecological Unit. Permanently convert island tracts (Little Holland, Liberty, and Prospect) at the south end of the Yolo Bypass to tidal wetland/slough complexes. Convert small tracts along Snodgrass Slough to tidal wetland/slough complexes. Construct setback levees along Minor, Steamboat, Oxford, and Elk Sloughs.

**PROGRAMMATIC ACTION 1B:** In the East Delta Ecological Unit, construct setback levees along the South Mokelumne River and connecting dead-end sloughs (Beaver, Hog, and Sycamore).

**PROGRAMMATIC ACTION 1C:** Convert deeper subsided (sunken) lands between dead-end sloughs in the East Delta Ecological Unit east of the South Mokelumne River channel either to overflow basins and nontidal wetlands or to land designated for agricultural use.

**PROGRAMMATIC ACTION 1D:** Remove levees that hinder tidal and floodflows in the headwater basins of east Delta dead-end sloughs (Beaver, Hog, and Sycamore) and allow these lands to be subject to flood overflow and tidal action.

**PROGRAMMATIC ACTION 1E:** Construct setback levees in the South Delta Ecological Unit along the San Joaquin River between Mossdale and Stockton.

**PROGRAMMATIC ACTION 1F:** Convert adjacent lands along the San Joaquin River between Mossdale and Stockton either to overflow basins and nontidal wetlands or to land designated for agricultural use.

**PROGRAMMATIC ACTION 1G:** Construct setback levees on corners of Delta islands along the San Joaquin River channel in the Central and West Delta Ecological Unit. Open leveed lands to tidal action where possible along the margins of the West Delta Ecological Unit.

*RATIONALE: Subjecting approximately 10% of existing Delta leveed lands to tidal action and floodflows will greatly enhance the floodwater and sediment retention capacity of the Delta. The tracts at the south end of the Yolo Bypass, along the South Mokelumne River, and along the San Joaquin River channel are logical choices for this because they have limited levee systems and are already at high flood risk. These lands have had limited subsidence (settling) and offer good opportunities for restoring tidal wetland/slough complexes.*

*The other significant area for setbacks is along the main channel of the San Joaquin River. "Cutting corners" on some islands where the levee length to land area maintained is now high would reduce levee construction and maintenance.*

## CENTRAL VALLEY STREAM TEMPERATURES

**IMPLEMENTATION OBJECTIVE:** Maintain, improve, and restore water temperature regimes (conditions) to meet life cycle needs of aquatic organisms.

**TARGET 1:** More frequently achieve mean daily water temperatures between 60°F and 65°F in the Delta channels in spring and fall to meet the temperature needs of salmon and steelhead migrating through or rearing in the Delta (◆).

**PROGRAMMATIC ACTION 1A:** Improve riparian (bankside) woodland habitats along migrating channels and sloughs of the Delta.

**PROGRAMMATIC ACTION 1B:** Improve SRA habitat along migration routes in Delta.

*RATIONALE: Maintaining water temperatures of less than 65 °F can improve survival of juvenile chinook salmon rearing in or migrating through the Delta. Maintaining maximum daily water temperatures in the channels and sloughs of the Sacramento-San Joaquin Delta Ecological Zone of less than 66 °F in the fall will ensure healthy conditions for upstream migrating adult chinook salmon and early emigrating juveniles. Improved riparian habitat along Delta channels and the spring flow events should maintain cooler spring temperatures in dry and normal years. Improved riparian and SRA habitat will help to maintain lower Delta water temperatures from spring through fall.*

## DELTA CHANNEL HYDRAULICS

**IMPLEMENTATION OBJECTIVE:** Establish and maintain a hydraulic regime in the Bay-Delta to provide migratory cues, create and maintain habitat, and facilitate species distribution and transport.

**TARGET 1:** Reestablish more natural internal Delta water flows in channels not designated to carry cross-Delta flow of water to south Delta pumping plants (◆).

**PROGRAMMATIC ACTION 1A:** Reduce velocities in selected Delta channels by increasing cross-sectional areas of channel via setback levees or by constricting flows into and out of the channels.

**PROGRAMMATIC ACTION 1B:** Restore 3,000 to 4,000 acres of tidal perennial aquatic habitat and 20,000 to 25,000 acres of tidally influenced freshwater marsh. *(Note: These recommendations are contained within programmatic actions presented in this vision for tidal perennial aquatic habitat and fresh emergent wetland (tidal) and are not additions to acreages presented in the targets and programmatic actions for habitat.)*

**PROGRAMMATIC ACTION 1C:** Restrict tidal flow and cross-Delta transfer of water to south Delta pumping plants to selected channels to lessen flow through other channels.

**PROGRAMMATIC ACTION 1D:** Manage the operation of existing physical barriers so that resulting hydraulics upstream and downstream of the barrier are more like levels in the mid-1960s.

**PROGRAMMATIC ACTION 1E:** Close the DCC when opportunities allow, as specified in the 1995 Water Quality Control Plan and recommended by USFWS (U.S. Fish and Wildlife Service 1995), in the period from November through January when appropriate conditions trigger closure (i.e., internal Delta exports are occurring).

**TARGET 2:** Maintain net downstream flows in the mainstem San Joaquin River from Vernalis to immediately west of Stockton from September through November to help sustain dissolved oxygen levels and water temperatures adequate for upstream migrating adult fall-run chinook salmon (◆◆).

**PROGRAMMATIC ACTION 2A:** Operate a barrier at the head of Old River from August through November.

**TARGET 3:** Restore 50 to 100 miles of tidal channels in the southern Yolo Bypass within the north Delta, while maintaining or improving the flood carrying capacity of the Yolo Bypass (◆). *(Note: this target is in addition to targets and programmatic actions presented in the Delta Slough habitat section.)*

**PROGRAMMATIC ACTION 3A:** Construct a network of channels within the Yolo Bypass to connect the Putah and Cache Creek sinks, and potentially the Colusa drain, to the Delta. These channels should effectively drain all flooded lands in the bypass after floodflows stop entering the bypass from the Fremont and Sacramento weirs. The channels would maintain a base flow through the spring to allow juvenile anadromous and resident fish to move from rearing and migratory areas.

**PROGRAMMATIC ACTION 3B:** Reduce flow constrictions in the Yolo Bypass such as those in the openings in the railway causeway that parallels Interstate 80.

***RATIONALE:*** *Internal Delta hydraulics have been highly modified since the early 1950s. Adverse hydraulic action has created poor conditions for sustaining spawning, rearing, and foodweb production in the Delta and for the transport of larval fish such as delta smelt; (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995; Independent Scientific Group 1996).*

*Helping to restore hydraulic conditions within the Delta by modifying physical barriers in the Delta will support natural transport functions, reduce entrainment (in diversions) into parts of the Delta where survival is low, and assist in transporting juvenile fish into and through the Delta to highly productive nursery areas in the western Delta and Suisun Bay. Modifying DCC operation will restore historical hydraulic conditions in lower Mokelumne channels of the north Delta (U.S. Fish and Wildlife Service 1994 Delta Smelt Biological Opinion; U.S. Fish and Wildlife Service 1995 Delta Smelt Opinion on the 1995 Water Quality Control Plan; U.S. Fish and Wildlife Service 1995).*

*Maintaining adequate flows past Stockton will improve existing harmful conditions of low dissolved oxygen and high water temperatures that can hinder the upstream movement of adult San Joaquin fall-run chinook salmon. In addition,* *improved flows past Stockton will reduce straying of adult salmon into Central and South Delta channels (California Department of Fish and Game 1972).*

*Improving the channel network in the Yolo Bypass will improve the migration pathway for salmon produced in Putah and Cache Creeks, as well as for upper Sacramento River salmon using the Yolo Bypass as a pathway to the Delta. A well-drained system with permanent sloughs will keep juvenile salmon from being stranded in the bypass when flows stop. Permanent sloughs will provide valuable juvenile salmon rearing habitat in late winter and early spring.*

*Improving habitats along riparian corridors in the Yolo Bypass will provide additional spawning and rearing habitat for splittail and rearing and migration habitat for juvenile chinook salmon and perhaps for delta smelt and other native resident fishes. Conditions will also improve for wildlife and waterfowl.*

*Restoring connections among Delta channels, freshwater marsh, and seasonal wetland habitats will enhance habitat conditions for special-status species such as the splittail. Restoring this habitat connectivity in a large-scale mosaic in the North Delta will help restore the ecosystem processes and functions fundamental to supporting the foodweb and will improve conditions for rearing chinook salmon, steelhead, sturgeon, juvenile delta smelt, striped bass, and splittail (Fahrig and Merriam 1985).*

### BAY-DELTA AQUATIC FOODWEB

**IMPLEMENTATION OBJECTIVE:** Maintain, improve, or restore the amount of basic nutrients available to estuarine and riverine systems to provide a sustainable level of foodweb productivity.

**TARGET 1:** Increase primary and secondary nutrient productivity in the Delta to levels historically observed in the 1960s and early 1970s (◆).

**PROGRAMMATIC ACTION 1A:** Actions described above to restore streamflow, floodplain flooding, Delta hydraulics, tidal wetlands and sloughs, and riparian habitat would increase primary and secondary productivity in the Delta. Relocating the intake of the South Delta pumping plants to the North Delta would also increase Delta productivity.

***RATIONALE:** Increasing the area of tidal wetland/slough habitat and the residence time of Delta waters will increase primary and secondary productivity. More flooding of floodplains will provide more nutrients and organic carbon inputs to Delta waters. Relocating the intakes of the South Delta pumping plants will increase the residence time of Central and South Delta waters and allow more of the highly productive San Joaquin waters to be retained in the Delta.*

## HABITATS

### GENERAL RATIONALE

*Restoring wetland and riparian habitats along with tidal perennial aquatic habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Zone. The extent and distribution of the land-water interface (contact) between aquatic habitats and interconnected wetland and riparian habitats have been altered since the mid-1850s by Delta reclamation. Since 1906, the amount of land-water interface has been reduced 32% in the East Delta Ecological Unit, 25% in the South Delta Ecological Unit, and 45% in the Central and West Delta Ecological Unit.*

*Restoring the ratio of land-water interface and increasing the shoreline perimeter will help restore a complex habitat mosaic on a large scale in the Delta. This will support essential ecosystem processes and functions. These measures are also fundamental to supporting the foodweb and improving conditions for rearing chinook salmon, steelhead, sturgeon, delta smelt, striped bass, and splittail. Foodweb support functions for wildlife will also benefit (Cummins 1974; Clark 1992).*

*Restoring high-quality freshwater marsh and brackish water marsh, both seasonal and permanent, will increase the production and availability of natural forage for waterfowl and other wildlife. This restoration will also increase the overwinter survival rates of wildlife that winter in this ecological zone and will strengthen them for migration, thus improving their breeding success. Expanding these habitats will also reduce the amount and concentrations of contaminants that could, upon entering the Delta's sloughs, damage the ecological health of the aquatic ecosystem.*

### TIDAL PERENNIAL AQUATIC HABITAT

**IMPLEMENTATION OBJECTIVE:** Increase the area of shallow-water and intertidal mudflat habitat to improve conditions that support increased primary and secondary productivity; provide rearing and foraging habitat, and escape cover for fish; and provide foraging and resting habitat, and escape cover for water birds.

**TARGET 1:** Restore 1,500 acres of shallow-water habitat in the North Delta Ecological Unit; 1,000 acres of shallow-water habitat in the East Delta Ecological Unit; 2,000 acres of shallow-water habitat in the South Delta Ecological Unit; and 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 1A:** Restore 500 acres of shallow-water habitat at Prospect Island in the North Delta Ecological Unit.

**PROGRAMMATIC ACTION 1B:** Restore 1,000 acres of shallow-water habitat in the downstream (south) end of the Yolo Bypass (Little Holland and Liberty Islands) within the North Delta Ecological Unit.

**PROGRAMMATIC ACTION 1C:** Restore 1,000 acres of shallow-water habitat at the eastern edge of the East Delta Ecological Unit where existing land elevations range from 5 to 9 feet below mean sea level.

**PROGRAMMATIC ACTION 1D:** Restore 2,000 acres of shallow-water habitat at the south and eastern edge of the South Delta Ecological Unit where existing land elevations range from 5 to 9 feet below mean sea level.

**PROGRAMMATIC ACTION 1E:** Restore 2,500 acres of shallow-water habitat in the Central and West Delta Ecological Unit where existing land elevations range from 5 to 9 feet below mean sea level. A program of fill placement or longer-term subsidence reversal may be needed to accomplish this action.

**TARGET 2:** Restore 500 acres of shoals in the westernmost portion of the Central and West Delta (◆◆).

**PROGRAMMATIC ACTION 2A:** Implement a sediment management program that results in deposition and accretion within portions of Central and West Delta channels and bays, forming 500 acres of shallow shoal habitat restored to tidal influence.

***RATIONALE:** Restoring, improving, and protecting high-quality shallow-water habitat will provide greater foraging areas for rearing juvenile fish and waterfowl in this ecological zone. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for waterfowl that use underwater vegetation growing in the shoals and for diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984; Shloss 1991; Sweetnam and Stevens 1993; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1996; Lindberg and Marzuola 1993).*

*Restoring, improving, and protecting high-quality shallow shoal habitat will provide foraging habitat for rearing juvenile fish. These areas typically provide high primary and secondary productivity and support nutrient cycling that sustains good forage. These areas also provide good forage for shorebirds that feed on invertebrates, waterfowl that use underwater vegetation growing in the shoals, and diving ducks such as canvasback and* *scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).*

## NONTIDAL PERENNIAL AQUATIC HABITAT

**IMPLEMENTATION OBJECTIVE:** Increase its amount in the Delta to provide improved foraging and resting habitat for water birds, particularly diving ducks, and help to restore and maintain the ecological health of the terrestrial and aquatic resources in and dependent on the Delta.

**TARGET 1:** Develop 500 acres of deep open-water areas (more than 4 to 6 feet deep) within restored fresh emergent wetlands in the Delta to provide resting habitat for water birds, foraging habitat for diving ducks and other water birds and semi-aquatic mammals that feed in deep water, and habitat for associated resident pond fish species (◆).

**PROGRAMMATIC ACTION 1A:** Develop 100 acres of open-water areas within restored fresh emergent wetland habitats in the West and Central Delta Ecological Unit such as on Twitchell or Sherman islands.

**PROGRAMMATIC ACTION 1B:** Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Unit.

**PROGRAMMATIC ACTION 1C:** Develop 200 acres of open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Unit.

**TARGET 2:** Develop 1,500 to 2,000 acres of shallow, open-water areas (less than 4 to 6 feet deep) in restored fresh emergent wetland habitat areas in the Delta to provide resting, foraging, and brood habitat for water birds and habitat for fish and aquatic plants and semi-aquatic animals (◆◆).

**PROGRAMMATIC ACTION 2A:** Develop 500 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the Central and West Delta Ecological Unit such as on Twitchell or Sherman Islands.

**PROGRAMMATIC ACTION 2B:** Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the East Delta Ecological Unit.

**PROGRAMMATIC ACTION 2C:** Develop 300 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the South Delta Ecological Unit.

**PROGRAMMATIC ACTION 2D:** Develop 1,000 acres of shallow, open-water areas within restored fresh emergent wetland habitats in the North Delta Ecological Unit.

***RATIONALE:** Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rate. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

*Restoring suitable resting areas for waterfowl and other wetland-dependent wildlife such as river otter will increase their over-winter survival rates. Other water-associated wildlife will also benefit (Madrone and Associates 1980).*

## DELTA SLOUGHS

**IMPLEMENTATION OBJECTIVE:** Protect and improve existing tidal slough habitat and restore a portion of the historical Delta slough distribution. Sloughs will be restored within tidally influenced freshwater emergent wetlands, mudflats, and seasonal floodplains.

**TARGET 1:** Restore ecological structure and functions of the Delta waterways network by increasing the land-water interface ratio a minimum of 50% to 75% compared to 1906 conditions and by restoring 100 to 150 miles of small distributary sloughs (less than 50 to 75 feet wide) hydrologically connected to larger Delta channels (◆◆). *(Note: This target is in addition to the Delta slough target presented in the target section for Delta Channel Hydraulics.)*

**PROGRAMMATIC ACTION 1A:** To replace lost slough habitat and provide high-quality habitat areas for fish and associated wildlife, the short-term solution for the Central and West Delta Ecological Unit is to restore 20 miles of slough habitat. The long-term solution is to restore 50 miles of slough habitat. In both the North Delta and East Delta Ecological Units, the short-term solution is to restore 10 miles of slough habitat. The long-term solution is to restore 30 miles of slough habitat. In the South Delta Ecological Unit, the short-term solution is to restore 25 miles of slough habitat and the long-term solution is to restore 50 miles of slough habitat.

**PROGRAMMATIC ACTION 1B:** Restore tidal action to portions of islands and tracts in the North and East Delta Ecological Units with appropriate elevation, topography, and water-landform conditions. This will sustain tidally influenced freshwater marshes with 20 to 30 linear miles of narrow, serpentine shaped sloughs within the wetlands and floodplain.

***RATIONALE:** Restoring, improving, and protecting sloughs in the ecological units of the Sacramento-San Joaquin Delta Ecological Zone will help sustain high-quality shallow-water habitat for spawning of native fish and for foraging of juvenile fish. Restoring small dead-end sloughs and tidally influenced freshwater marshes and mudflats in the Sacramento-San Joaquin Delta Ecological Zone will provide habitat for spawning of native fish and for foraging of juvenile fish, increase production of primary and secondary food species, and support nutrient cycling that sustains quality forage. These sloughs can also provide loafing sites for waterfowl and habitat for the western pond turtle (Simenstad et al. 1992 and 1993; Lindberg and Marzuola 1993; Madrone and Associates 1980).*

*Land-water interface targets represent a reasonable level necessary to restore Bay-Delta ecosystem functions and overall health by increasing water-to-perimeter shoreline ratios and patterns to those of the early 1900s.*

## MIDCHANNEL ISLANDS AND SHOALS

**IMPLEMENTATION OBJECTIVE:** Protect and enhance existing remnant channel islands in the Delta. Prioritize island restoration starting with those that have greatest chance to be maintained by restored streamflow patterns, hydraulic conditions, sediment transport, and other restored ecosystem processes.

**TARGET 1:** Maintain existing channel islands and restore 50 to 200 acres of high-value islands in selected sloughs and channels in each of the Delta's ecological units (◆◆).

**PROGRAMMATIC ACTION 1A:** Actively protect and improve existing channel islands in the Delta.

**PROGRAMMATIC ACTION 1B:** Restore 50 to 200 acres of channel islands in the Delta where channel islands once existed.

***RATIONALE:** Many of the remnant channel or "berm" islands in the Delta have been lost to continuing erosion and degradation. Restoring, improving, and protecting the riverine-edge habitat of these islands will provide habitat for juvenile salmon rearing in this ecological zone. Terrestrial vertebrates that will receive indirect benefits include the western pond turtle and shorebirds and wading birds (Fris and DeHaven 1993; Mahoney and Ermin 1984; Knight and Bottorf 1983; Knox 1984; Novick and Hein 1982; Moore and Gregory 1988; May and Levin 1991; Levin et al. 1995).*

*Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These habitats typically provide high levels of primary (plant) and secondary (animal) productivity and support nutrient cycling functions that can sustain quality forage. These habitats also provide high-quality forage habitat for waterfowl who use submergent vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984).*

*Restoring high-quality brackish tidal marshes on and adjacent to these islands will contribute to cycling nutrients, maintaining the foodweb, and increasing production of primary and secondary food species in a geographic location already noted for its value as a rearing habitat for estuarine fish. Several plant species of special concern such as the Suisun aster will benefit from increasing the area of brackish tidal marsh in the Delta (Landin and Newling 1988; Dionne et al. 1994; Lindberg and Marzuola 1993).*

### FRESH EMERGENT WETLAND HABITAT (TIDAL)

**IMPLEMENTATION OBJECTIVE:** Protect and enhance existing wetlands by restoring tidally influenced freshwater emergent wetland in the Delta. This will:

- provide high-quality habitat for waterfowl, shorebirds, and other associated wildlife;
- provide rearing, foraging, and escape cover for fish; and
- expand the populations and ranges of associated special-status, federally listed, and State-listed plant and animal species.

This will help to restore and maintain the ecological health of the aquatic resources in and dependent on the Delta.

**TARGET 1:** Increase existing tidal freshwater marshes habitat in the Delta by restoring 30,000 to 45,000 acres of lands designated for floodplain restoration (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop tidal freshwater marshes on Prospect, Little Holland, and Liberty Islands in the North Delta Ecological Unit.

**PROGRAMMATIC ACTION 1B:** Develop tidal freshwater marshes on small tracts of converted leveed lands along Snodgrass Slough.

**PROGRAMMATIC ACTION 1C:** Develop tidal freshwater marshes along the upper ends of dead-end sloughs in the east Delta.

**PROGRAMMATIC ACTION 1D:** Develop tidal freshwater marshes along all setback levees and levees with restored riparian habitat.

**PROGRAMMATIC ACTION 1E:** Develop tidal freshwater marshes on restored channel island habitat.

*RATIONALE: Restoring tidally influenced freshwater marshes in the Sacramento-San Joaquin Delta Ecological Zone will increase production of primary and secondary food species and support nutrient cycling functions that can sustain quality forage conditions for fish, waterfowl, shorebirds, and wildlife (Lindberg and Marzuola 1993; Miller 1993; Simenstad et al. 1992 and 1993). Increasing the area of freshwater tidal marshes in each of the four Delta ecological units will help support the proper aquatic habitat for rearing and outmigrating juvenile chinook salmon, steelhead, and sturgeon and for rearing delta smelt, striped bass, and splittail. Restoring high-quality freshwater marshes, both tidal and nontidal, will contribute to nutrient cycling, maintaining the foodweb, and increased production of primary and secondary food species.*

*Increasing the area of nontidal freshwater marsh in the Delta, particularly in the Central and West Delta Ecological Unit, will be an important component of subsidence control and island accretion. Permanent freshwater marshes can help arrest and in some cases reverse subsidence where peat oxidation has resulted in land elevations more than 15 feet below sea level. Increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. Habitats for wetland wildlife will be improved.*

*The targets selected take into account the large losses of tidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Zone lost nearly 90,000 acres, with the greatest losses in the North Delta and Central and West Delta Ecological Units. Acreage changes in* *the South Delta were insignificant during that period because most losses these occurred before 1900. Restoration targets are to restore between 30% and 50% of the losses since 1900. The level of restoration was increased in the South Delta because of the prior losses documented by Landin and Newling (1988).*

### FRESH EMERGENT WETLAND HABITAT (NONTIDAL)

**IMPLEMENTATION OBJECTIVE:** Restore nontidal fresh emergent wetland in the Delta to provide high-quality habitat for special-status plants and animals, waterfowl, shorebirds, and other associated wildlife. This will help to restore and maintain the ecological health of the aquatic resources in and dependent on the Delta.

**TARGET 1:** Restore a total of 3,000 acres of nontidal freshwater marshes in the North and the East Delta Ecological Units; restore 4,000 acres of nontidal fresh emergent wetland in the South Delta Ecological Unit as part of a subsidence control program; and restore 10,000 acres of nontidal fresh emergent wetland in the Central and West Delta Ecological Unit as part of a subsidence control program (◆◆).

**PROGRAMMATIC ACTION 1A:** Restore 1,000 acres of nontidal freshwater marshes on Twitchell Island.

**PROGRAMMATIC ACTION 1B:** Restore 1,000 acres of nontidal freshwater marshes in the Yolo Bypass.

**PROGRAMMATIC ACTION 1C:** Restore 1,000 acres of nontidal freshwater marshes in leveed lands designated for floodplain overflow adjacent to the dead-end sloughs in the East Delta Ecological Unit.

**PROGRAMMATIC ACTION 1D:** Restore 4,000 acres of nontidal freshwater marshes in the South Delta in lands designated for floodplain overflow.

**PROGRAMMATIC ACTION 1E:** Restore 10,000 acres of nontidal freshwater marshes on Delta Islands of the Central and West Delta Ecological Unit.

***RATIONALE:** The restoration of high-quality nontidal freshwater marshes will contribute to nutrient cycling, maintaining the foodweb, and supporting enhanced levels of primary and secondary food production. Increasing the areal extent of nontidal freshwater marsh in the Delta, particularly in the Central and West Delta Ecological Unit, will be an important component of subsidence control and island accretion. Permanent freshwater marsh can help arrest and in some cases reverse subsidence where peat oxidation has resulted in land elevations more than 15 feet below sea level. Increasing the area of freshwater marsh will contribute to an ecosystem that can accommodate sea level rise. Habitats for wetland wildlife will be improved. The targets selected take into account the large losses of nontidal freshwater marshes since the early 1900s. The Sacramento-San Joaquin Delta Ecological Zone lost nearly 90,000 acres with the greatest losses in the North Delta and Central and West Delta Ecological Units. Acreage changes in the South Delta were insignificant during that period because most losses there occurred before 1900.*

### SEASONAL WETLAND HABITAT

**IMPLEMENTATION OBJECTIVE:** Restore and manage seasonal wetland habitat in the Delta to:

- restore foodweb and floodplain processes,
- reduce the effects of contaminants and water management on the Delta's aquatic resources; and
- provide high-quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds.

This will help to restore and maintain the ecological health of the aquatic resources in and dependent on the Delta.

**TARGET 1:** Restore and manage at least 4,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the North Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 1A:** Improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the Yolo Bypass.

**PROGRAMMATIC ACTION 1B:** Restore and manage 2,000 acres of additional seasonal wetland habitat in association with the Yolo Basin Wildlife Area.

**TARGET 2:** Restore and manage at least 6,000 acres of additional seasonal wetland habitat and improve management of 1,000 acres of existing, degraded seasonal wetland habitat in the East Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 2A:** Restore and manage 1,000 acres of additional seasonal wetland habitat on Canal Ranch.

**PROGRAMMATIC ACTION 2B:** Restore and manage 5,000 acres of additional seasonal wetland habitat.

**PROGRAMMATIC ACTION 2C:** Improve management of 1,000 acres of existing degraded seasonal wetland habitat.

**TARGET 3:** Restore and manage at least 8,000 acres of additional seasonal wetland habitat and improve management of 1,500 acres of existing, degraded seasonal wetland habitat in the Central and West Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 3A:** Restore and manage 4,000 acres of additional seasonal wetland habitat on both Twitchell and Sherman Islands.

**PROGRAMMATIC ACTION 3B:** Restore and manage 4,000 acres of additional seasonal wetland habitat on Sherman Island.

**PROGRAMMATIC ACTION 3C:** Develop a cooperative program to improve management of 1,500 acres of existing degraded seasonal wetland habitat.

**TARGET 4:** Restore and manage at least 12,000 acres of additional seasonal wetland habitat and improve management of 500 acres of existing, degraded seasonal wetland habitat in the South Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 4A:** Develop a cooperative program to restore and manage 12,000 acres of additional seasonal wetland habitat.

**PROGRAMMATIC ACTION 4B:** Develop a cooperative program to improve management of 500 acres of existing degraded seasonal wetland habitat.

**TARGET 5:** Restore and manage an additional 20,000 to 30,000 acres of seasonal wetland habitat throughout all Delta ecological units (◆◆). (Wetlands can be developed on lands designated for floodplain expansion.)

**PROGRAMMATIC ACTION 5A:** Develop a cooperative program to restore and manage additional seasonal wetland habitats throughout the Sacramento-San Joaquin Delta Ecological Zone in addition to the acreages presented in Targets 1 through 4.

*RATIONALE: Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Sacramento-San Joaquin Delta Ecological Zone. The amount of land-water interface between aquatic habitats and wetland and riparian habitats has been altered by the reclamation of Delta lands since the mid-1850s.*

*Restoring the ratio of land-water interface will help restore a mosaic of complex habitats that will restore important ecosystem processes and functions. Restoring these habitats will also reduce the amount and concentrations of contaminants that could, once they enter the Delta's sloughs, interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

*Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions for the Delta aquatic zone, most of the seasonal wetlands of the Sacramento-San Joaquin Delta Ecological Zone should be subject to periodic flooding and overland flow from Delta and river floodplains.*

### RIPARIAN AND RIVERINE AQUATIC HABITATS

**IMPLEMENTATION OBJECTIVE:** Restore riparian scrub, woodland, and forest habitat along largely nonvegetated riprapped banks of Delta island levees, along the Sacramento and San Joaquin Rivers, and along major tributaries of the Sacramento and San Joaquin Rivers. This will create corridors of riparian vegetation to shade riverine aquatic habitat for anadromous and other fish species, and to create high-quality habitat for special-status plant and animal species and other wildlife.

**TARGET 1:** Restore 10 to 20 linear miles of riparian and riverine aquatic habitat along the San Joaquin River in the South Delta Ecological Unit to create corridors of riparian vegetation of which 50% is to be over 75 feet wide and 40% is to be no less than 300 feet wide and 1 mile long (◆◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

**TARGET 2:** Restore 15 to 25 linear miles of riparian and riverine aquatic habitat along other Delta island levees throughout the South Delta Ecological Unit. This will create riparian vegetation corridors of which 60% is to be more than 75 feet wide and 10%, no less than 300 feet wide and 1 mile long (◆◆).

**PROGRAMMATIC ACTION 2A:** Develop a cooperative program to restore riparian habitat either by obtaining conservation easements or by purchase from willing sellers.

**TARGET 3:** Restore 10 to 15 linear miles of riparian and riverine aquatic habitat along the Sacramento River below Sacramento (◆).

**PROGRAMMATIC ACTION 3A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore 10 to 15 linear miles of riparian habitat along the Sacramento River in the North Delta Ecological Unit. Obtain conservation easements for, or purchase from willing sellers, land needed to create corridors of riparian vegetation.

**TARGET 4:** Restore 8 to 15 linear miles of riparian and riverine aquatic habitat in the East Delta Ecological Unit (◆◆).

**PROGRAMMATIC ACTION 4A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore 5 to 10 linear miles along the Mokelumne River and 3 to 5 miles along the Cosumnes River in the East Delta Ecological Unit to create corridors of riparian vegetation.

**TARGET 5:** Restore or plant riparian and riverine aquatic habitats and recreate slough habitat and set back levees (◆).

**PROGRAMMATIC ACTION 5A:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along newly created sloughs and sloughs with new levee setbacks.

**PROGRAMMATIC ACTION 5B:** Obtain conservation easements for, or purchase from willing sellers, land needed to restore riparian habitat along new or upgraded Delta levees.

**TARGET 6:** Protect existing riparian woodlands in North, East, and South Delta Ecological Units (◆◆).

**PROGRAMMATIC ACTION 6A:** Expand the Stone Lakes and Cosumnes River Preserves from their current size by an additional 500 acres of existing woodland habitat. Share costs with the Nature Conservancy to acquire in-fee title to the lands needed from willing landowners.

**PROGRAMMATIC ACTION 6B:** Purchase riparian woodland property or easements.

*RATIONALE: Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the Central Valley are dependent on or closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than any other habitat type in California. Degradation and loss of riparian habitat has substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support.*

*Restoring, improving, and protecting high-quality riparian woodland habitat will enhance nutrient cycling and foodweb support and provide habitat for terrestrial invertebrates that will sustain resident fish and rearing juvenile anadromous fish in the Delta. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, wading birds, neotropical birds, and the riparian brush rabbit. This habitat will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; Knight and Bottorff 1983).*

*Large-scale riparian restoration projects are needed to restore the biodiversity (variety of species) and the sustainability and resilience of these habitats. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large landscape scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994). Large-scale restoration of broad, diverse riparian habitats in the Sacramento-San Joaquin Delta Ecological Zone will support increased nesting populations of Swainson's hawks and other raptors, as well as the yellow-billed cuckoo. Wood ducks will also benefit from increases in riparian habitat. Heron and egret rookeries will increase as well (Baltz and Moyle 1984; Hudson 1991; Motroni 1981; National Resource Council 1992; Gaines 1974 and 1977).*

*Riparian woodland habitats are important habitat use areas for many species of wildlife in the Central Valley. The loss or degradation of historic stands of riparian woodland has substantially reduced the habitat area available for associated wildlife. Such woodlands will also contribute to the recovery of species such as Swainson's hawk. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; splittail; and delta smelt. These actions will also benefit the Swainson's hawk, greater sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake, as well as plant species such as rose mallow, Mason's lilaeopsis, marsh mudwort, Sanford's arrowleaf, Jepson's tule pea, and Antioch dunes evening primrose.*

## INLAND DUNE SCRUB

**IMPLEMENTATION OBJECTIVE:** Improve low- to moderate-quality Antioch inland dune habitat in the Delta to provide high-quality habitat for special-status plant and animal species and associated wildlife.

**TARGET 1:** Enhance 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat in the Delta to provide high-quality habitat for special-status plant and animal species and associated wildlife (◆◆).

**PROGRAMMATIC ACTION 1A:** Support programs for protecting and restoring inland dune scrub habitat at existing ecological preserves in the Central and West Delta Ecological Unit.

**PROGRAMMATIC ACTION 1B:** Protect and restore inland dune scrub habitat areas adjacent to existing ecological preserves in the Central and West Delta Ecological Unit through either conservation easements or purchase from willing sellers.

***RATIONALE:** An analysis of soils indicated that the historical extent of inland sand dunes in the Delta was probably less than 10,000 acres. The extent and habitat quality of inland dune scrub has declined as a result of recent land use changes. Inland dune scrub is a unique Delta community and supports several special-status plant and animal species, including the Lange's metalmark, which is federally listed as endangered. Protection and restoration of inland dune scrub habitat will help maintain existing special-status species and assist in recovery of their populations.*

## PERENNIAL GRASSLAND

**IMPLEMENTATION OBJECTIVE:** Increase the area of perennial grasslands by restoring perennial grasses along with restoration of floodplains and marshes to provide high-quality habitat conditions for associated special-status plant and wildlife species.

**TARGET 1:** Restore 4,000 to 6,000 acres of perennial grasses in the North, East, South, and Central and West Delta Ecological Units associated with existing or proposed wetlands and floodplain habitats (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to restore 1,000 acres of perennial grassland in the North Delta Ecological Unit through either conservation easements or purchase from willing sellers.

**PROGRAMMATIC ACTION 1B:** Develop a cooperative program to restore 1,000 acres of perennial grassland in the East Delta Ecological Unit through either conservation easements or purchase from willing sellers.

**PROGRAMMATIC ACTION 1C:** Develop a cooperative program to restore 2,000 acres of perennial grassland in the South Delta Ecological Unit through either conservation easements or purchase from willing sellers.

***RATIONALE:** Restoring wetland, riparian, and adjacent upland habitats in association with aquatic habitats is an essential element of the restoration strategy for this ecological zone. Eliminating fragmentation and restoring connection of habitats will enhance habitat conditions for special-status species such as the California black rail and foraging habitat for Swainson's hawk. For instance, the habitats for these species have been degraded by a loss of the adjacent escape cover needed during periods of high flows or high tides.*

## AGRICULTURAL LANDS

**IMPLEMENTATION OBJECTIVE:** Cooperatively manage agricultural lands to provide high quality wildlife values for associated species, and maintain or increase the economic viability of agricultural lands.

**TARGET 1:** Cooperatively manage 40,000 to 75,000 acres of agricultural lands (◆◆).

**PROGRAMMATIC ACTION 1A:** Increase the area of Delta corn fields and pastures flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

**PROGRAMMATIC ACTION 1B:** Periodically flood pasture from October through March in portions of the Delta relatively free of human disturbance to create suitable roosting habitat for wintering greater sandhill crane, and for other wintering sandhill crane subspecies.

**PROGRAMMATIC ACTION 1C:** Create permanent or semipermanent ponds in Delta farm areas that provide suitable waterfowl nesting habitat but lack suitable brooding habitat, to increase resident dabbling duck production.

**PROGRAMMATIC ACTION 1D:** Increase the acreage farmed for wheat and other crops that provide suitable nesting habitat for waterfowl and other ground-nesting species in the Delta.

**PROGRAMMATIC ACTION 1E:** Convert agricultural lands in the Delta from crop types of low forage value for wintering waterfowl, wintering sandhill cranes, and other wildlife to crop types of greater forage value.

**PROGRAMMATIC ACTION 1F:** Defer fall tillage on corn fields in the Delta to increase the forage for wintering waterfowl, wintering sandhill cranes, and associated wildlife.

**PROGRAMMATIC ACTION 1G:** Develop a cooperative program to improve management on 8,000 acres of Delta corn and wheat fields and to reimburse farmers for leaving a portion of the crop in each field unharvested as forage for waterfowl, sandhill cranes, and other wildlife.

***RATIONALE:*** *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.*

*Reducing the nutrients entrainment of lower trophic organisms (food species) such as phytoplankton and zooplankton, and of life stages of higher trophic organisms such as fish eggs, larvae, and juveniles into agricultural and export water diversions will increase production of primary and secondary food species. This will also support nutrient cycling functions that can sustain quality forage for aquatic resources in and dependent on the Delta (Chadwick 1974).*

*Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).*

*Restoring roosting habitat in this ecological zone, especially when it is near forage habitat, will increase the overwinter survival of sandhill cranes and strengthen them for migration, thus improving breeding success. Decreasing in human disturbance in the roosting sites will also improve the health of the crane in the Delta. Actions to restore ecological processes and functions, increase and improve habitats, and reduce stressors are prescribed primarily to increase populations of lower level food species, aquatic and terrestrial invertebrates, and forage fish such as threadfin shad. Improving the foodweb of the Delta will help restore the health of the Bay-Delta's aquatic ecosystem.*

*Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the red-legged frog, tiger salamander, giant garter snake, and western pond turtle will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground-nesting birds.*

*Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to* *increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and Ringelman 1990). Following the extensive loss of native upland habitats, upland wildlife species have adapted to the artificial upland environment of some agricultural land uses and have become dependent on agricultural upland areas and field-border shelter belts to sustain their populations.*

*Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success. (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).*

*Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success. (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).*

*Management of agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success. (Madrone and Assoc. 1980; Fredrickson and Reid 1988; Schultz 1990; and, Ringelman 1990).*

## REDUCING OR ELIMINATING STRESSORS

### WATER DIVERSIONS

**IMPLEMENTATION OBJECTIVE:** Reduce entrainment of aquatic organisms and nutrients at water diversions to increase survival of juvenile fish and maintain the foodweb.

**TARGET 1:** Reduce loss of important fish species at diversions (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Consolidate and screen agricultural diversions in the Delta.

**PROGRAMMATIC ACTION 1B:** Replace or upgrade the screens at the SWP and CVP intakes with positive-barrier, fish bypass screens and state-of-the-art fish holding and transportation systems.

**PROGRAMMATIC ACTION 1C:** Upgrade screens at Pacific Gas & Electric Company's Contra Costa power plant with fine-mesh, positive barrier, fish bypass screens.

***RATIONALE:*** *Loss of juvenile fish in diversions is detrimental to fish species of special concern (Chadwick and Von Geldern 1964; Larkin 1979; California Department of Fish and Game 1990; Erkkila et al. 1950).*

### LEVEES, BRIDGES, AND BANK PROTECTION

**IMPLEMENTATION OBJECTIVE:** Reestablish natural vegetation within narrow levees, consistent with flood protection needs and new levee vegetation management guidelines approved by the Bureau of Reclamation (Reclamation) Board, on 50 to 175 miles of levee in the Sacramento-San Joaquin Delta Ecological Zone.

**TARGET 1:** Increase shoreline and floodplain riparian habitat in the Delta by changing the vegetation maintenance practices on both the water and the land side of berms on 25 to 75 miles of the Sacramento, Mokelumne, and San Joaquin Rivers, and on 25 to 100 miles of other Delta channels and sloughs confined by levees (◆◆).

**PROGRAMMATIC ACTION 1A:** Enter into agreements with willing levee reclamation districts to change levee and berm vegetation management practices that to establish and mature shoreline riparian vegetation. This will restore and maintain the health of Delta aquatic resources. Reimburse districts for any additional maintenance and inspection costs.

***RATIONALE:*** *Restoring, improving, and protecting high-quality riparian woodland and willow scrub habitat will enhance nutrient cycling and the* *foodweb and provide habitat for terrestrial invertebrates that will sustain resident fish and juvenile anadromous fish. Terrestrial vertebrates that will benefit include the Swainson's hawk, western yellow-billed cuckoo, neotropical migrant songbirds, and the riparian brush rabbit. This action will also increase suitable habitat for wildlife such as the western pond turtle and wood duck (Bjornn et al. 1991; Shields et al. 1993; Jensen et al. 1987; Fris and DeHaven 1993; Mahoney and Erman 1984; and Knight and Bottorff 1983). Large-scale riparian restoration projects are needed to restore the variety of species and the sustainability and resilience of these habitats to support the ecological functions needed for aquatic resource restoration in the Bay-Delta. This is consistent with the recommended strategy for restoration of rivers and aquatic ecosystems on a large scale (National Research Council 1992; Noss and Harris 1986; Hutto et al. 1987; Scott et al. 1987; Noss et al. 1994).*

## DREDGING AND SEDIMENT DISPOSAL

**IMPLEMENTATION OBJECTIVE:** Reduce the loss of and degradation to important aquatic habitat and vegetated berm islands caused by dredging, thereby protecting, restoring, and maintaining the health of Delta aquatic resources.

**TARGET 1:** Limit dredging in channel zones that are not essential for flood conveyance or maintenance of industrial shipping pathways, and avoid dredging in shallow water areas (depths of less than 3 meters at mean high water) except where it is needed to restore flood conveyance capacity (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Use alternate sources (rather than Delta inchannel sources) of levee maintenance material, such as:

- excavation of abandoned nonessential levees,
- excavation material from the restoration of secondary tidal channels,
- dry-side island interior borrow pits,
- upland borrow sites,
- Cache Creek settling basin and Yolo Bypass sediment deposits, and
- deep water dredging sites in the San Francisco Bay.

**PROGRAMMATIC ACTION 1B:** Restrict or minimize effects of dredging near existing midchannel tule islands and shoals that are vulnerable to erosion and exhibit clear signs of area reduction from channel and bar incision (cutting).

**IMPLEMENTATION OBJECTIVE:** Reduce impacts of dredging on aquatic resources during the main spawning and rearing periods and in sensitive areas. This will help protect, restore, and maintain the health of Delta aquatic resources.

**TARGET 2:** Avoid dredging during spawning and rearing periods for delta smelt and during rearing periods for winter-run chinook salmon (◆◆◆).

**PROGRAMMATIC ACTION 2A:** Follow DFG guidelines for dredging in the estuary.

**PROGRAMMATIC ACTION 2B:** Provide stockpiles of levee maintenance materials in three or more selected land-side areas to avoid the need to obtain material from Delta channels during restricted periods.

***RATIONALE:** Soils for levee maintenance should not be taken from adjacent Delta waters because such dredging alters the physical and chemical characteristics of the aquatic habitat and disrupts aquatic organisms. Restoring, improving, and protecting high-quality shallow habitat will provide forage for rearing juvenile fish. These areas typically produce high levels of primary and secondary food species and support nutrient cycling that can sustain quality forage. These areas also provide high-quality forage for waterfowl that use submergent vegetation growing in the shoals and diving ducks such as canvasback and scaup that eat clams in these areas (Fris and DeHaven 1993; Brittain et al. 1993; Stuber 1984). Losses or impacts to this habitat should be avoided to restore the health of the estuary (Schlosser 1991; Sweetnam and Stevens 1993; Herbold 1994).*

*Impacts that could disrupt foraging and breeding activities of special-status estuarine fish should be avoided (Sweetnam and Stevens 1993; Moyle et al. 1992, Herbold 1994).*

## INVASIVE AQUATIC PLANTS

**IMPLEMENTATION OBJECTIVE:** Reduce adverse effects of invasive non-native aquatic plants to increase and maintain the productivity of the aquatic foodweb, preserve suitable fish habitat, and provide quality habitat for native submergent and emergent plants.

**TARGET 1:** Manage existing and restored dead-end and open-ended sloughs and channels within the Sacramento-San Joaquin Delta Ecological Zone so that less than 1% of the surface area of these sloughs and channels are covered by invasive non-native aquatic plants (◆).

**PROGRAMMATIC ACTION 1A:** Conduct large-scale, annual weed eradication programs throughout existing and restored dead-end and open-ended sloughs and channels within each of the Delta's ecological units. The goal is that less than 1% of the surface area of these sloughs and channels is to be covered by invasive non-native aquatic plants within 10 years.

**Target 2:** Reduce the potential for introducing non-native aquatic plant and animal species at border crossings (◆◆◆).

**PROGRAMMATIC ACTION 2A:** Provide funding to the California Department of Food and Agriculture to expand the current State border inspection process to include a comprehensive program of exclusion, detection, and management of invasive aquatic species such as the zebra mussel, purple loosestrife, and hydrilla.

***RATIONALE:** Invasive aquatic plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those from competition for nutrients, light, and space. The prescribed action is primarily to enhance foodweb functions and improve habitat for resident, estuarine, and anadromous fish and neotropical migratory birds, in part, by reducing the areas inhabited by invasive non-native plants and by large-scale restoration of optimal nesting habitat (Dudley and D'Antonio 1994; Anderson 1990; Zedler 1992; Bay-Delta Oversight Council 1994).*

*Every reasonable effort should be made to reduce the introduction of non-native organisms at overland entrances to California. Inspections at borders have already found Zebra mussels that if allowed to enter Bay-Delta waters could have devastating economic and ecological effects.*

## INVASIVE RIPARIAN AND SALT MARSH PLANTS

**IMPLEMENTATION OBJECTIVE:** Reduce populations of invasive nonnative tree and shrub species that compete with the establishment and succession of native riparian vegetation in the Sacramento-San Joaquin Delta Ecological Zone. Achieving this objective would assist in the natural reestablishment of native riparian vegetation in floodplains, increase SRA cover for fish, increase habitat values for riparian wildlife, and restore and maintain the health of Delta aquatic resources.

**TARGET 1:** Reduce surface area covered by non-native plants to less than 1% (◆).

**PROGRAMMATIC ACTION 1A:** Control non-native riparian plants.

**TARGET 2:** Reduce the area of invasive non-native woody species, such as Giant Reed (i.e., arundo or false bamboo) and eucalyptus, that compete with native riparian vegetation, by reducing the area of non-natives by 50% throughout the Delta and by eradicating invasive woody plants from restoration areas (◆◆).

**PROGRAMMATIC ACTION 2A:** Implement a program throughout the Delta to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation by reducing the aerial extent of species such as False Bamboo and eucalyptus by 50%.

**PROGRAMMATIC ACTION 2B:** Implement a program throughout the Delta that, before restoration actions, eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

*RATIONALE: Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat throughout the Delta (Dudley and D'Antonio 1994; Madrone and Assoc. 1980; Bay-Delta Oversight Council 1994; Cross and Fleming 1989; Zedler 1992).*

## INVASIVE AQUATIC ORGANISMS

**IMPLEMENTATION OBJECTIVE:** Reduce introductions of non-native aquatic organisms that compete or displace native species.

**TARGET 1:** Reduce or eliminate the influx of non-native aquatic species in ship ballast water (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Fund additional inspection staff to enforce existing regulations.

**PROGRAMMATIC ACTION 1B:** Help fund research on ballast water treatment techniques that could eliminate non-native species before ballast water is released.

*RATIONALE: Every reasonable effort should be made to reduce the introduction of non-native organisms in the ballast water of ships that enter the Delta. Such organisms have greatly altered the zooplankton of the Delta over the past several decades. Further alteration could reduce the capacity of the Delta to support native fishes.*

## PREDATION AND COMPETITION

**IMPLEMENTATION OBJECTIVE:** Reduce the loss of juvenile anadromous and resident fish and other aquatic organisms from unnatural levels of predation. This will increase survival and contribute to the restoration of important species.

**TARGET 1:** Reduce loss of juvenile fish in Clifton Court Forebay to predation (◆).

**PROGRAMMATIC ACTION 1A:** Develop a cooperative program to reevaluate the need to remove predatory fish from Clifton Court Forebay.

**PROGRAMMATIC ACTION 1B:** Evaluate alternative methods to remove predator fish from Clifton Court Forebay with emphasis on predator removal near the fish facility.

**PROGRAMMATIC ACTION 1C:** Evaluate alternate operational strategies to reduce entrainment of juvenile fish into Clifton Court Forebay.

*RATIONALE: Diversions and other humanmade structures may provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern (Chadwick and Von Geldern 1964; Larkin 1979; California Department of Fish and Game 1990; Erkkila et al. 1950).*

*Predation of juvenile fish in Clifton Court Forebay is a symptom of larger problems. These are probably insufficient rearing habitat in the Central Delta, high channel velocities, and insufficient flows in the San Joaquin River. Short-term efforts in Clifton Court Forebay should include, at a minimum, a predator removal or control program near the fish facility and louver system. Additional focused research is needed on longer-term efforts to reduce predation and to improve the understanding of predator population growth. The longer-term solution to predation at this site lies in re-creating rearing and migration habitats throughout the Delta. Some of the water conveyance alternatives in the Delta could decrease the rates of predation in the forebay by closing the radial gates for longer periods and perhaps by diverting water at the radial gates during periods when fewer predators are likely to enter the forebay.*

## CONTAMINANTS

**IMPLEMENTATION OBJECTIVE:** Reduce concentrations and loadings of contaminants in the aquatic environment and the subsequent bioaccumulation of them in aquatic species. This will increase species survival and eliminate public health concerns.

**TARGET 1:** Reduce loading, concentrations, and bioaccumulation of contaminants of concern to ecosystem health in the water, sediments, and tissues of fish and wildlife in the Sacramento-San Joaquin Delta Ecological Zone by 25 to 50% as measured against current average levels (◆◆).

**PROGRAMMATIC ACTION 1A:** Reduce the input of herbicides, pesticides, fumigants, and other agents toxic to fish and wildlife in the Delta by changing land management practices and chemical uses on 50,000 acres of urban and agricultural lands that drain untreated into Delta channels and sloughs. Actions will focus on modifying agricultural practices and urban land uses on a large scale. To reduce the concentration of pesticide residues, the amount applied will be reduced and the amount of pesticide load reaching the Delta's aquatic habitats will be further reduced by taking advantage of biological and chemical processes within wetland systems to help break down harmful pesticide residues.

**PROGRAMMATIC ACTION 1B:** Reduce levels of hydrocarbons and other contaminants entering the Delta foodweb from high releases into the estuary at oil refineries.

***RATIONALE:*** *Reducing the concentrations and loads of contaminants including hydrocarbons, heavy metals, and other pollutants in the water and sediments of the Sacramento-San Joaquin Delta Ecological Zone will help ensure reduction of sublethal and chronic impacts of contaminants, whose impacts on population levels are hard to document. (Bay Delta Oversight Council 1994; Hall 1991; U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Sparks 1992; Diamond et al. 1993; Rost et al. 1989).*

*Improved inchannel flows within the Delta from seasonal reductions in water use and improved flows attributed to enhanced supplies of environmental water will also contribute to reducing concentrations (Charbunneau and Resh 1992; U.S. Environmental Protection Agency 1993). Human health warnings associated with consuming fish and wildlife have been issued because of high levels of substances such as mercury and selenium. Large-scale restoration of aquatic and wetland habitats may contribute to reducing levels of hydrocarbons, heavy metals, and other pollutants. However, addressing point sources of concern such as the oil refineries on Suisun and San Francisco Bays and elevated releases of selenium as a result of refining oil from sources high in selenium can also help reduce these contaminants (Charbunneau and Resh 1992).*

## HARVEST OF FISH AND WILDLIFE

**IMPLEMENTATION OBJECTIVE:** This implementation objective seeks to regulate harvest of fish and wildlife enough to avoid impairing the reproductive capacity of the population in relation to available habitat.

**TARGET 1:** Reduce illegal harvest of anadromous fish and wildlife in the Delta by increasing enforcement (◆◆◆).

**PROGRAMMATIC ACTION 1A:** Provide additional funding to the DFG for additional enforcement.

**PROGRAMMATIC ACTION 1B:** Provide additional funding to local county sheriff's departments and and local park agencies for additional enforcement.

**PROGRAMMATIC ACTION 1C:** Provide rewards for the arrest and conviction of poachers.

***RATIONALE:*** *Actions to reduce illegal harvest of fish and wildlife are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as Swainson's hawk, greater* *sandhill crane, yellow-billed cuckoo, riparian brush rabbit, black rail, and giant garter snake (U.S. Fish and Wildlife Service 1996; San Francisco Estuary Project 1992b; Bay-Delta Oversight Council 1993; California Department of Fish and Game 1991).*

### DISTURBANCE

**IMPLEMENTATION OBJECTIVE:** Manage boat traffic in sensitive habitat areas to reduce boat wake erosion and to protect or buffer the remaining channel islands from boat wake erosion.

**TARGET 1:** Reduce boat traffic and boat speeds in areas where levees or channel islands and their associated shallow-water and riparian habitat may be damaged by wakes. This will protect important Delta habitats such as berm islands from erosion caused by boat wake (◆◆).

**PROGRAMMATIC ACTION 1A:** In the Central and West Delta Ecological Unit, establish and enforce no wake zones of 1 to 3 miles in Disappointment Slough, of 1 to 2 miles in White Slough, and of 3 to 4 miles in Middle and Old Rivers in areas with remnant berms and midchannel islands.

**PROGRAMMATIC ACTION 1B:** In the East Delta Ecological Unit, establish and enforce no wake zones of 1 to 3 miles of the Mokelumne River, of 2 to 4 miles in Snodgrass Slough, and of 3 to 4 miles in Beaver, Hog, and Sycamore Sloughs in areas with remnant berms and midchannel islands.

**TARGET 2:** Reduce boat wakes near designated important California black rail nesting areas in the Delta from March to June to levels necessary to prevent destruction of nests. This will help in recovery of this listed species (◆◆).

**PROGRAMMATIC ACTION 2A:** Establish and enforce no wake zones within 50 yards of important California black rail nesting areas in the Delta from March to June.

**PROGRAMMATIC ACTION 2B:** Establish and enforce no motorized boating zones in 5 to 25 miles of existing dead-end channels in the Delta from March to June.

**PROGRAMMATIC ACTION 2C:** Establish and enforce no motorized boating zones in the small tidal channels created in restored tidal freshwater marshes and Delta floodplains of levee setbacks.

***RATIONALE:** Protecting the highest quality and largest berm island complexes will advance the ERPP's strategy of protecting and restoring large areas of habitat rather than small fragmented areas (National Research Council 1992; Resource Agency 1976; San Francisco Estuary Project 1992a; San Joaquin County 1979; U.S. Fish and Wildlife Service 1992).*

*Actions taken to restore ecological processes and functions, increase and improve habitats, and reduce stressors in this ecological zone are prescribed primarily to contribute to the recovery of aquatic species such as winter-run, spring-run, and late-fall-run chinook salmon; green sturgeon; splittail; and steelhead. They will also contribute to the recovery of species such as the black rail. (Madrone 1980; Schlosser 1991; San Francisco Estuary Project 1992a; U.S. Fish and Wildlife Service 1978; Schlorff 1991).*

## SPECIES

### DELTA SMELT

**IMPLEMENTATION OBJECTIVE:** Ensure the recovery of this species, which is and federally listed as threatened. Recovery of delta smelt would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include recovery goals tied to the fall midwater trawl survey and the distribution of catch in various zones of the trawl survey (◆◆).

**PROGRAMMATIC ACTIONS:** Restoring delta smelt will come indirectly from increasing March to May Delta inflow and outflow, improving Delta water temperature, improving Delta channel hydraulics, improving the Delta aquatic foodweb, improving aquatic wetland, and riparian habitats, and reducing stressors including the effects of water diversions and contaminants.

*RATIONALE: Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the delta smelt population. Without such an increase, there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young delta smelt survival, and by providing transport flow to larval delta smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay. Reducing water temperatures in the Delta in spring and summer should benefit delta smelt because they are a cool water species that become stressed at highest Delta water temperatures. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult delta smelt.*

### LONGFIN SMELT

**IMPLEMENTATION OBJECTIVE:** Ensure the recovery of this species of special concern. Recovery of longfin smelt would contribute to species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include recovery goals tied to the fall midwater trawl survey and the distribution of catch in various zones of the trawl survey, and catch goals in the Suisun Marsh trawl survey (◆◆).

**PROGRAMMATIC ACTIONS:** Restoration of longfin smelt will come indirectly from:

- increasing March to May Delta inflow and outflow,
- improving Delta water temperature,
- improving Delta channel hydraulics,
- improving the Delta aquatic foodweb,
- improving aquatic wetland, and riparian habitats, and
- reducing stressors including the effects of water diversions, contaminants, and the stocking of striped bass and chinook salmon in longfin smelt nursery areas of North San Francisco Bay.

*RATIONALE: Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the longfin smelt population. Without such an increase in the population, there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving into the Delta to spawn, by stimulating aquatic foodweb production to help ensure young longfin smelt survival, and by providing transport flow to larval longfin smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay.*

*Reducing water temperatures in the Delta in spring and summer should benefit longfin smelt as they are a cool water species that become stressed at highest Delta water temperatures. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult longfin smelt. Reevaluation of stocking striped bass and chinook salmon into prime nursery habitats of longfin smelt in San Pablo Bay and Suisun Bay would reduce predation on young longfin smelt. Alternative locations and time of stocking may limit predation on longfin smelt.*

### SPLITTAIL

**IMPLEMENTATION OBJECTIVE:** Ensure the recovery of this species which is proposed for listing under the federal Endangered Species Act (ESA) and a candidate for listing under the California ESA. Recovery of splittail would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include recovery goals tied to the fall midwater trawl survey and distribution of catch in various zones of the trawl survey (◆◆).

**PROGRAMMATIC ACTIONS:** Restoration of splittail will come indirectly from increasing March to May Delta inflow and outflow, improving Delta water temperature, improving Delta channel hydraulics, improving the Delta aquatic foodweb, improving aquatic wetland, and riparian habitats, and reducing stressors including effects of water diversions and contaminants.

*RATIONALE: Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the splittail population. Without such an increase there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the population by providing attraction flow to adults moving upstream into the Delta and rivers to spawn, by increasing flooding of riparian vegetation which is important spawning habitat of splittail, by stimulating aquatic foodweb production to help ensure young splittail survival, and by providing transport flow to larval delta smelt to move them from the Delta into prime nursery habitat in the western Delta and Suisun Bay. Reducing water temperatures in the Delta in spring and summer should benefit delta smelt because they are a cool water species that become stressed a highest Delta water temperatures. Improving channel hydraulics would increase the aquatic foodweb and improve spawning and rearing habitat. Improving shallow water, slough, and wetland habitats should increase the spawning and rearing habitat of splittail. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult splittail.*

### WHITE STURGEON AND GREEN STURGEON

**IMPLEMENTATION OBJECTIVE:** Restore the distribution and abundance of the white sturgeon to historical levels to support a sport fishery and to assist in the recovery of the green sturgeon, a California Department of Fish and Game species of special concern. Meeting this objective would reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include 100,000 white sturgeon and 2,000 green sturgeon greater than 100 cm long as measured in the DFG mark-recapture program (◆◆).

**PROGRAMMATIC ACTIONS:** Restoration of sturgeon will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors including effects of water diversions and contaminants.

*RATIONALE: Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the sturgeon populations. Without such an increase there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young sturgeon survival, and by providing transport flow to larval sturgeon to move them from the rivers into prime nursery habitat in the Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult sturgeon.*

### CHINOOK SALMON

**IMPLEMENTATION OBJECTIVE:** Contribute to the recovery of the Sacramento winter-run chinook salmon, a species listed as endangered under the federal and State Endangered Species Acts (ESAs). Recovery of winter-run chinook salmon would ensure species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta. The objective is also to contribute to the restoration of Sacramento fall-run, spring-run, late-fall-run, and San Joaquin fall-run chinook salmon to support viable sport and commercial fisheries.

**TARGET:** Meet the goals of the Winter-Run Chinook Salmon Recovery Plan (National Marine Fishery Service 1997, in preparation), the Native Fishes Recovery Plan (US Fish and Wildlife Service 1996), and the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997 in preparation) (◆◆).

**PROGRAMMATIC ACTIONS:** Restoring chinook salmon populations will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants.

*RATIONALE: Meeting the targets of the Winter-Run Chinook Salmon Recovery Plan, the Native Fish Recovery Plan, and the Anadromous Fish Recovery Plan will indicate an increase in the chinook salmon populations. Without such an increase there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young survival, and by providing transport flow to juvenile salmon to move them from the rivers into prime nursery habitat in the Delta and Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult salmon.*

### STRIPED BASS

**IMPLEMENTATION OBJECTIVE:** Restore its population levels to those of the 1960s to contribute to a recreational fishery in the Bay-Delta. Increased population levels of striped bass would reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the striped bass recovery program (California Department of Fish and Game 1997, in preparation), which include a target of 2,000,000 to 3,000,000 adult fish as measured in the DFG mark-recapture study (◆).

**PROGRAMMATIC ACTIONS:** Restoring striped bass will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; increasing shallow water, riparian, and wetland habitats in the Delta; and reducing stressors including effects of water diversions and contaminants. To meet target population level may require, at least in the short-term, supplementing young production through artificial rearing and stocking of young striped bass salvaged at south Delta fish facilities or raised in hatcheries.

*RATIONALE: Meeting the targets of the Striped Bass Recovery Plan will indicate an increase in the striped bass population. Without such an increase there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving into and through the Delta to spawn, by stimulating aquatic foodweb production to help ensure survival young, and by providing transport flow to juvenile striped bass to move them from the rivers and Delta into prime nursery habitat in the western Delta and Suisun Bay. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult* *striped bass. Stocking of artificially reared striped bass may be necessary to reach target levels of adults needed to support a quality fishery of striped bass; however, such stocking of artificially reared striped bass should not come at the expense of healthy populations of native resident and anadromous fish.*

### AMERICAN SHAD

**IMPLEMENTATION OBJECTIVE:** Maintain naturally spawning populations that will support sport fisheries similar to those that existed in the 1960s and 1970s to contribute to the recreational use of the Bay-Delta. Meeting this objective would reduce the conflict between the need for protection of this species and other beneficial uses of water in the Bay-Delta.

**TARGET:** The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years (◆).

**PROGRAMMATIC ACTIONS:** Restoring American shad populations will come indirectly from increasing March to May Delta inflow and outflow, improving Delta channel hydraulics, improving the Delta aquatic foodweb, and reducing stressors, including the effects of water diversions and contaminants.

***RATIONALE:*** *Meeting the targets of the Anadromous Fish Recovery Plan will indicate an increase in the American shad population. Without such an increase there would be no guarantee that the target is being met. Improved spring inflow and outflow should benefit the populations by providing attraction flow to adults moving through the Delta into the rivers to spawn, by stimulating aquatic foodweb production to help ensure young shad survival, and by providing transport flow to juvenile shad to move them from the rivers into prime nursery habitat in the lower rivers and Delta. Improving channel hydraulics would increase the aquatic foodweb and improve juvenile rearing habitat. Reducing the effects of water diversions and contaminants would help to improve survival of young and adult shad.*

### RESIDENT FISH SPECIES

**IMPLEMENTATION OBJECTIVE:** Maintain and restore the distribution and abundance of resident native fish species, such as Sacramento blackfish, hardhead, tule perch, and Sacramento perch, and non-native species, such as white catfish, largemouth bass, and threadfin shad, to support a sport fishery and healthy forage populations. Meeting this objective would contribute to species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Meet the goals of the Native Fish Recovery Plan (US Fish and Wildlife Service 1996), which include improving habitat of native fishes and restoring the population of Sacramento perch (◆).

**PROGRAMMATIC ACTIONS:** Restoration of native resident species will come indirectly from increasing March to May Delta inflow and outflow; improving Delta channel hydraulics; improving the Delta aquatic foodweb; improving aquatic, wetland, and riparian habitats; and reducing stressors including effects of water diversions and contaminants.

***RATIONALE:*** *Meeting the targets of the Native Fish Recovery Plan will indicate an increase in the native fish populations. Without such an increase there would be no guarantee that recovery is occurring. Improved spring inflow and outflow should benefit the populations by stimulating aquatic foodweb production. Improving channel hydraulics would increase the aquatic foodweb and improve spawning, rearing, and feeding habitat of native resident fishes. Reducing the effects of water diversions and contaminants would help to improve survival of young and adults. Improvements in habitats and reductions in stressors may allow the successful reintroduction of Sacramento perch.*

## MARINE/ESTUARINE FISHES AND LARGE INVERTEBRATES

**IMPLEMENTATION OBJECTIVE:** Maintain, improve, and restore populations of these species to levels that existed in the early 1980s in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years (◆).

**PROGRAMMATIC ACTION:** General programmatic actions that will contribute to the target include improving winter/spring Delta outflow, restoring tidal wetland habitat, improving the aquatic foodweb, reducing losses of larvae and juvenile marine/estuarine fishes at water diversions in the Bay and Delta, limiting the introductions of non-native species, and reducing the input of toxic substances into Central Valley waterways.

***RATIONALE:*** *There are many species of marine/estuarine fish and larger invertebrates that live in and depend on the Bay or Delta for at least a portion of their life cycles. Some of these are important contributors to the ecological health and well being of estuarine, freshwater, and anadromous fish that inhabit the Bay-Delta. Some, such as the Pacific herring, northern anchovy, starry flounder, shiner perch, Dungeness crab, and bay shrimp, depend at least partially on the Bay-Delta as a nursery for young. At times, some of these species are among the most abundant in the Bay-Delta and are essential elements of the foodweb that supports important fish such as chinook salmon, white sturgeon, and striped bass.*

*The abundance of starry flounder, Pacific herring, bay shrimp, shiner perch, and other species appears related to the amount of freshwater outflow to the Bay. Freshwater outflow contributes to food production, estuarine flow patterns, habitat conditions, and water quality. While some species, such as the Pacific herring, spawn in the Bay, others spawn in the ocean and their young migrate into the Bay and Delta, aided by tidal and gravitational currents.*

*The abundance of starry flounder, Pacific herring, bay shrimp, and shiner perch as measured in California Department of Fish and Game (DFG) Bay trawling surveys declined during the 1987-1992 drought; some recovery was evident by 1995. Generally, low abundance occurred in drier years, with this pattern particularly apparent for bay shrimp, starry flounder, and Pacific herring. For most of the marine/estuarine species, factors relating to the marine environment are also important and effects are difficult to separate from estuary factors.*

*Low abundance of marine/estuarine species has occurred along with a number of other changes in the estuary that could be a factor in suppressing populations. Factors related and believed to contribute to low marine/estuarine fish abundance in the Bay-Delta include the following:*

- *Low outflows in late winter and spring are believed to reduce movement of young marine/estuarine fish into the Bay and Delta. This would reduce foodweb production, which affects the survival and production of marine/estuarine fish. Low flows are a consequence of low rainfall and more precipitation falling as winter rains than as snow and limited winter and spring runoff in dry and normal years being held in basin storage reservoirs.*
- *Low Delta outflows limit transport of larvae and juveniles upstream into the Delta from the Bay by limiting estuarine circulation. (Higher Delta outflow of freshwater on the surface, provides greater up-estuary transport of marine waters along the bottom.)*
- *Loss of larvae and juveniles into water diversions in Suisun Bay, Suisun Marsh, and the Delta may reduce production, especially in drier years when the percentage of freshwater diverted is sharply higher than that in wetter years.*

- *Toxic water and sediment may also reduce the survival of marine/estuarine fish in the Bay and Delta. The effect may be indirect through poor plankton food supply or direct through egg, larvae, or juvenile poisoning.*

*Other factors possibly contributing to the reduced abundance of marine/estuarine fish and large invertebrates include competition or predation by recently established non-native fishes. Two of the dominant non-native species, gobies and Asia clams, were introduced from ballast water of ships from Asia. Changes in the plankton foodweb from non-native species may also be contributing to the decline.*

## BAY-DELTA AQUATIC FOODWEB ORGANISMS

**IMPLEMENTATION OBJECTIVE:** Restore the estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton.

**TARGET:** Increase populations and distribution of important foodweb organisms in Delta channels and reduce competition with invasive non-native species (♦♦).

**PROGRAMMATIC ACTION:** Actions in the Sacramento-San Joaquin Delta Ecological Zone that will contribute to reaching the target for Bay-Delta aquatic foodweb organisms include improvements to ecological processes such as Central Valley streamflows, natural floodplain and flood processes, and Delta channel hydraulics; improving habitats such as tidal perennial aquatic habitat, Delta sloughs, and fresh emergent wetland habitat; and the reduction or elimination of the adverse effects of stressors such as water diversion, dredging and sediment disposal, invasive aquatic plants, invasive aquatic organisms, and contaminants.

***RATIONALE:** Restoring populations of important foodweb organisms through restoration of important ecological processes, aquatic habitats, and reducing the effects of stressors will benefit juvenile fishes that rear in the Delta. These species include delta smelt, longfin smelt, chinook salmon, and striped bass.*

## WESTERN SPADEFOOT AND CALIFORNIA TIGER SALAMANDER

**IMPLEMENTATION OBJECTIVE:** Assist in the recovery of both species of special concern in the Bay-Delta in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Increase populations of amphibians particularly tiger salamanders and spadefoot toads by increasing natural flood plains, stream meander, and seasonal pools (♦).

**PROGRAMMATIC ACTIONS:** These species will benefit indirectly from restoration of natural flood plains. A regulated management grazing program could benefit vernal pool habitats that support these species. Mowing and cattle grazing should be minimized near seasonal wetlands utilized by either species from October to March. Reduce mortality from vehicle deaths, especially during the brief window when tiger salamanders and spadefoots are migrating by locating restored habitat in areas well removed from regular vehicle traffic. Reduce fumigants to control rodents should be used only from October to March in known occupied habitats since rodent burrows are required during the summer. Draining pertinent water ways during the native species' dormant season could result in a reduction in populations of large, introduced, predatory fish and bullfrogs.

***RATIONALE:** Western spadefoot toad and California tiger salamander populations have declined primarily as a result of habitat loss or degradation and competition or predation from non-native species. The abundance from population to population is unknown but is influenced by the size and quality of habitat within the fragmented pockets that the species are known to inhabit.*

*The western spadefoot toad is primarily a lowlands species, frequenting washes, river floodplains, alluvial fans, playas, and alkali flats, but also ranges into the foothills and mountain valleys. Tiger salamanders typically inhabit scattered ponds, intermittent streams, or vernal pools that are associated with grassland-oak woodland habitat below Elevation 1500. Vernal pools covering more than 250 square feet, with fairly turbid water, provide optimal habitats. Most surface movements of the western spadefoot and California tiger salamander, including breeding activity, are associated with the onset of late-winter and early spring rains that fill traditional breeding ponds. Warm days followed by rains or high humidity levels at night trigger reproductive and foraging activities and adults of these species sometimes appear in large numbers.*

*The greatest threat to the continued existence of both species is habitat loss and competition by non-native species. Habitat loss is a result of increased urbanization and conversion of native grasslands to agriculture. The spadefoot and salamander may be found in high densities in isolated areas but adjacent breeding habitat is increasingly being converted for other uses.*

*Introduction of predatory fish and bullfrogs in known breeding ponds is also an important factor attributed to the decline of these species. Juvenile bullfrogs are thought to compete with and prey on larvae of these native species. Other important stressors that affect the spadefoot and salamander are rodent control activities, which reduce the availability of summer estivation (burrowing) sites, and development of roads between breeding ponds and terrestrial habitats, resulting in deaths from automobiles during the species' migrations.*

## California Red-legged Frog

**Implementation Objective:** Restore the distribution and abundance of red-legged frog to levels that will help assist in its recovery. Recovery of this species will contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

**Target 1:** Create viable, self-sustaining populations of red-legged frog while enhancing existing and restored aquatic habitats for other native species (◆).

**Programmatic Action 1A:** Develop watershed management plans to protect riparian and wetland areas occupied by red-legged frogs.

**Target 2:** Manage restored aquatic and wetland habitat to minimize predation on red-legged frog by non-native fish, bullfrogs, and crayfish (◆).

**Programmatic Action 2A:** Reduce exotic predators such as bullfrogs, black bass, sunfish, and crayfish and restore habitat by creating canals, side channels, and backflow pools containing emergent vegetation. Provide the critical components of reproductive, forage and escape cover.

***Rationale:** In areas where livestock graze in watersheds inhabited by red-legged frogs, management plans should be developed to protect habitats and increase the potential of maintaining adequate water quality, especially in drought years. Also, manage habitats occupied by red-legged from to avoid or minimize detrimental agricultural practices such as discing, mowing, burning, and application of herbicides and pesticides.*

*Restoring the habitats for this species will also result in restoration of habitat for special status plant species and rare plant associations.*

*The introduction of non-native fish, bullfrogs, and crayfish has reduced the distribution of red-legged frogs throughout their range. These species prey and larval, juvenile, and adult red-legged frogs. Restoration of this species requires quality aquatic habitats that are protected from invasion by non-native species and other human induced disturbances associate with land use practices.*

### Giant Garter Snake and Western Pond Turtle

**Implementation Objective:** Assist in the recovery of the giant garter snake, a federally listed threatened species, and the western pond turtle, a species of special concern. Meeting this objective would contribute to species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

**Target:** Restore at least five core areas of suitable habitat, each consisting of about 500 acres in each of the North, East, and South Delta ecological units (◆◆).

**Programmatic Actions:** Enhance existing poor habitats and restore new habitats in historical wetlands, grasslands, and upland areas.

*Rationale: Restoration of the giant garter snake and western pond turtle will come indirectly from restoration of large areas of native Delta marshes and adjacent grasslands in areas where remnant habitats and populations of the snake and turtle now exist.*

### Swainson's Hawk

**Implementation Objective:** Assist in the recovery of this State-listed threatened species. Recovery of Swainson's hawk would contribute to species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

**Target:** Restore nesting density to nine nesting pairs per 100 square miles; improve foraging habitat on Delta land; and increase riparian forest and oak woodlands (◆◆◆).

**Programmatic Actions:** Restore riparian woodlands and improve wildlife habitat values on agricultural lands. *(Note: Please refer to the implementation objectives, targets, and programmatic actions in the habitat section of the Sacramento-San Joaquin Delta Ecological Zone for acreages and general areas for restoration of riparian, perennial grassland, and agricultural lands.)*

*Rationale: Because Swainson's hawks are migratory birds and dependent on many factors outside the Delta, improvement of habitat, especially breeding habitat in the Delta, is an important piece of their recovery. Restoring riparian forest habitat will provide breeding habitat, and improving wildlife habitat on agricultural lands will provide the necessary foraging habitat for breeding hawks.*

### California Black Rail

**Implementation Objective:** Assist in the recovery of this State-listed threatened species. Recovery of the California black rail would contribute to species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

**Target:** Enhance and restore tidal marshes and adjacent perennial grassland habitats in the Delta (◆◆).

**Programmatic Actions:** Restoring tidal marsh habitat would indirectly benefit California black rail population.

*Rationale: Restoring large areas of freshwater marsh is necessary to the recovery of the black rail, because it was uniquely dependent on the marshes that once dominated the landscape of the Bay-Delta. Targets and programmatic actions to restore freshwater marshes, perennial grassland, and agricultural lands are presented in the habitat section of the implementation objectives, targets, and programmatic actions for the Sacramento-San Joaquin Delta Ecological Zone.*

### Greater Sandhill Crane

**Implementation Objective:** Assist in the recovery of this State-listed threatened species. Recovery of the greater sandhill crane would contribute to species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

**TARGET:** Establish two new suitable roosting habitat areas in the Delta; enhance foraging habitat on agricultural lands; restore perennial grasslands in the East Delta ecological unit, and restore seasonally managed nontidal marshes in the East Delta ecological unit (◆◆◆).

**PROGRAMMATIC ACTIONS:** Restoring nontidal emergent wetland, perennial grasslands, and agricultural foraging habitat would indirectly benefit the greater sandhill crane population.

***RATIONALE:** Restoring large areas of freshwater marshes and perennial grasslands adjacent to agricultural lands with enhanced foraging value for cranes will help their recovery. Programmatic actions to contribute to improved habitat for the greater sandhill crane are presented in the habitat section of the implementation objectives, targets, and programmatic actions for the Sacramento-San Joaquin Delta Ecological Zone.*

### SHOREBIRDS AND WADING BIRDS

**IMPLEMENTATION OBJECTIVE:** Maintain and restore the distribution and abundance of shorebirds and wading birds to contribute to species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Improve populations and distribution of shorebirds and wading birds (◆◆).

**PROGRAMMATIC ACTIONS:** Shorebirds and wading birds will indirectly benefit from restoration of wetlands and tidal and nontidal perennial aquatic habitat (ponds and lakes).

***RATIONALE:** Restoring large areas of freshwater marshes and adjacent ponds and lakes will provide feeding and nesting habitat for many species of shorebirds and wading birds.*

### RIPARIAN BRUSH RABBIT

**IMPLEMENTATION OBJECTIVE:** Restore the distribution and abundance of the riparian brush rabbit to levels that will help assist in its recovery.

**TARGET 1:** Increase the population of riparian brush rabbits by 200 percent over current estimates so that a census of the riparian brush rabbit population would be two times higher than the current estimate of 213 to 312 individuals (◆◆).

**PROGRAMMATIC ACTION 1A:** Reestablish 500 acres of large contiguous areas of riparian forest habitat that have dense brushy understories with adjacent upland habitat. These restored/reestablished riparian forests would have adjacent upland habitat with sufficient cover. Establish five additional populations elsewhere within the historic range of the riparian brush rabbit; each population should have a self-sustaining populations with a minimum of 250 individuals each. Maintain and establish connectivity between key habitats.

**PROGRAMMATIC ACTION 1B:** Prohibit ground cover and litter removal to allow for dense brushy and herbaceous areas of a minimum size of 550 square yards within the riparian forest.

**PROGRAMMATIC ACTION 1C:** More closely approximate the natural hydrological regime which allows for establishment and maintenance of mature riparian forest habitat. Additionally, encourage growth of wild rose, coyote bush, blackberries, elderberries, wild grape, box elder, valley oak, and cottonwoods to provide habitat.

**PROGRAMMATIC ACTION 1D:** Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to the Park could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times.

**PROGRAMMATIC ACTION 1E:** Provide fire breaks around current and expanded habitat to protect habitat destruction due to wildfire and control feral cat and dog population with yearly control efforts within and adjacent to the Park. Prohibit dogs within Caswell Memorial State Park.

***RATIONALE:*** *The remaining population of riparian brush rabbit is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. Unlike other rabbits, the riparian brush rabbit occupies riparian forests that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species' habitat was throughout the floodplain on the valley floor in northern San Joaquin Valley, including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded.*

*The remnant population of riparian brush rabbit is now restricted to 260 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park in southern San Joaquin County in the East San Joaquin Basin Ecological Zone. It is considered the most sensitive mammal in California because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities. The large-scale loss of riparian forest has resulted in over a 99% decline in the riparian brush rabbit population from historical levels. A population census of the conducted during January 1993, found that the current population size ranges from about 210 to 310 individuals.*

*Overall, the decline of the riparian brush rabbit was caused by the destruction, fragmentation, and degradation of the San Joaquin Valley native riparian forest habitat. Less than 6% of the original habitat remains. Remaining suitable habitat is so severely fragmented that the rabbit has no means of naturally dispersing to other areas and establishing additional populations. Because the remaining riparian brush rabbit population occurs within one small area, any of the following events threaten the remaining population:*

- *Caswell Memorial State Park is subject to periodic flooding that often inundates the entire area. Without adequate cover on adjacent upland areas, the rabbits become easy targets for both native and non-native predators.*
- *The normal buildup of downed logs, dried vegetation, and ground litter in the riparian forest increases the potential severity of wildfires. Although this type of habitat is preferred and typically occupied by the riparian brush rabbit, any wildfire occurring within the remaining habitat could cause direct mortality as well as massive habitat destruction.*
- *Human activities have modified the habitat. The modified habitat has "selected" against the riparian brush rabbit and for the desert cottontail. The desert cottontail presents two threats: one from competition and the other from diseases common to rabbits and carried by the species. These diseases are typically contagious and fatal; any disease becomes epidemic in this small and restricted population of rabbits.*

## WATERFOWL

**IMPLEMENTATION OBJECTIVE:** Maintain and restore the distribution and abundance of waterfowl to contribute to species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

**TARGET:** Improve populations and distribution of waterfowl (◆◆).

**PROGRAMMATIC ACTIONS:** Waterfowl will indirectly benefit from restoration of sloughs, marshes, riparian, and tidal and nontidal ponds and lakes.

***RATIONALE:*** *Restoring large areas of riparian habitat freshwater marshes, and adjacent ponds and lakes will provide feeding and nesting habitat for many species of waterfowl.*

## Upland Game

**Implementation Objective:** The implementation objective for upland game is to restore and maintain healthy populations at levels that can support both consumptive and nonconsumptive uses. Maintaining and restoring the distribution and abundance of the upland game in the Delta will contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

**Target 1:** Increase the populations and distribution of upland game (◆◆).

**Programmatic Action 1A:** Upland game will indirectly benefit from restoration of wetlands, perennial grasslands, riparian, and improved management of agricultural lands in the Delta.

**Programmatic Action 1B:** Provide high ground adjacent to current and expanded habitat with cover for protection from floods. Existing flood control levees adjacent to agricultural lands could be utilized for this escape habitat in this area to provide sufficient vegetative growth of grasses, forbs, and shrubs to lower predation pressure during these times and when adjacent lands are fallow.

***Rationale:** Restoring populations of upland game with a focus on ring-necked pheasant and morning dove will improve the status of these two species in the Delta. Actions prescribed to improve seasonal wetlands, riparian, and enhanced agriculture using wildlife friendly farming methods will benefit both species. Enhancing nesting for both species and maintaining the productivity of the area's seasonal wetlands, riparian, and remaining agricultural lands will continue to support healthy populations of upland game dependent on this ecological zone.*

## Neotropical Migratory Birds:

**Implementation Objective:** Maintain healthy populations in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

**Target:** Increase the abundance and distribution of neotropical migratory birds in the Central Valley (◆◆).

**Programmatic Actions:** The following types of general programmatic actions will assist in meeting the target for neotropical migratory birds:

- increase wetland, riparian, grassland, and agricultural habitats,
- improve watershed health,
- improve specific nesting habitats for individual species within their existing and restored habitats, and
- protect nesting habitats from predators and human disturbance.

***Rationale:** The neotropical migratory bird guild comprises bird species that breed in North America and winter in Central and South America. Representative species of the neotropical migratory bird guild are the western kingbird, western wood-pewee, tree swallow, cliff swallow, northern oriole, Wilson's warbler, and yellow-breasted chat. Individual visions are developed for some neotropical migrants, such as the Swainson's hawk and yellow-billed cuckoo, and those visions contain more specific targets relating to those species. All species of the neotropical migratory bird guild depend on the flora of California to forage and reproduce, typically from about May until September. The birds normally spend the rest of the year in Central and South America.*

*Neotropical birds occur throughout the California and are associated with most of California's habitat types, including forested woodlands, riparian and montane riparian habitats, unforested lowlands, grasslands, shrub habitats, valley foothill hardwood, valley foothill hardwood-conifer, and wetlands. Population levels of many of these species has declined, primarily as a result of the loss and degradation of habitats on which they depend, both in California and on their Central and South American wintering areas. In*

*California, the quality and quantity of important neotropical migrant bird habitats have been substantially reduced primarily by their conversion to agricultural, industrial, and urban uses, and land use practices that degrade the values provided by these habitats. Achieving the implementation objectives for the western yellow-billed cuckoo and Swainson's hawk will also help achieve the implementation objectives for other neotropical migratory birds as well.*

## LANGE'S METALMARK, DELTA GREEN GROUND BEETLE, VALLEY ELDERBERRY LONGHORN BEETLE

**IMPLEMENTATION OBJECTIVE:** The implementation objective for the Lange's Metalmark, Delta Green Ground Beetle, and Valley Elderberry Longhorn Beetle is to assist in the recovery of these special status species. Recovery of these species will contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta. Restoring the habitats for these species will result in the restoration of important and rare plant associations.

**TARGET 1:** Increase populations of Lange's Metalmark by increasing Antioch inland dune habitat. Increase the area of suitable habitat to 60 acres from the only 15 acres of suitable habitat within the Antioch Dunes Ecological Reserve. Increase the population of adult butterflies at the Little Corral site by doubling late 1977 population estimates of 400 to 800 (◆◆).

**PROGRAMMATIC ACTIONS:** Increase populations of Delta Green Ground Beetle by establishing and securing habitat to support three additional viable and self-sustaining colonies of the Delta green ground beetle and maintain the existing populations.

Increase populations of Valley Elderberry Longhorn Beetle by expanding and linking isolated areas supporting populations of Valley elderberry longhorn beetle along portions of Putah Creek and Delta channels; minimizing the use of herbicides, insecticides, and other toxic substances; and promoting elderberry habitat by removing 50% of the exotic plants (e.g. Chinese tree-of-heaven, black locust, scotch broom) found in existing elderberry beetle habitat. Minimizing the use of herbicides, insecticides, and other toxic substances and preventing or minimizing activities that are incompatible with habitat maintenance: including riprapping levee construction, agricultural land conversion, overgrazing, and dredging will all help increase the populations of this species.

**RATIONALE:** *The preferred habitat of Lange's metalmark, a butterfly, is inland dune scrub. The Lange's metalmark is dependent on its host plant, naked buckwheat. The present range of Lange's metalmark has been reduced to only 15 acres of suitable habitat within the Antioch Dunes Ecological Reserve. Over a 9-day sampling period in 1977, biologists estimated that only 400 adult butterflies remain at the Little Corral site. A wide variety of stressors (e.g., land use, wildfire, non-native plant species, gravel mining, fences, and human-related disturbance) that degrade this species' habitat have contributed to the endangered status of Lange's metalmark.*

*The delta green ground beetle is found at the Jepson Prairie Preserve in Solano County, which is in the Yolo Basin Ecological Zone. The delta green ground beetle and its soft-bodied prey species depend on moist environments such as those provided by Olcott Lake and vernal pools within the Jepson Prairie Preserve. Vernal pools and aquatic seasonal habitats supply the critical needs of the delta green ground beetle. Entomologists believe that appropriate conditions for the species are found in open, moist habitats with limited vegetative cover.*

*Since 1974, entomologists have seen or collected only 75 adult delta green ground beetles in the preserve area. Although the historical distribution of the delta green ground beetle is unknown, the widespread disruption of wetland and grassland habitats in the Central Valley over the last 150 years strongly suggests that the range of the beetle has been reduced and fragmented. Today, the* *beetle predominately inhabits the borders of vernal pools and Olcott Lake at the Jepson Prairie Preserve. The primary threats to the survival of the delta green ground beetle have been, and continue to be, loss and alteration of its wetland habitat primarily because of agricultural conversion (i.e., the plowing and leveling of land); grazing; river channelization; and construction of dams, drainage ways, and pipelines.*

*VELB has been found only in association with its host plant, elderberry (Sambucus spp.). Elderberry is a component of the remaining riparian forests and adjacent grasslands of the Central Valley. Entomologists estimate that the range of this beetle extends from Redding at the northern end of the Central Valley to the Bakersfield area in the south. Important stressors on VELB are fragmentation of riparian habitat; grazing; and excessive collection of the species for commercial, recreational, scientific, or educational purposes. Local populations can also be severely damaged by pesticides inadvertently drifting from nearby agricultural lands into occupied habitat areas.*
*Restoring of vernal pool habitats, inland dune scrub, and riparian forest complexes with a significant elderberry composition will improve the status of these three species in the Bay-Delta.*

### WESTERN YELLOW-BILLED CUCKOO

**IMPLEMENTATION OBJECTIVE:** Assist in the recovery of this State-listed endangered species. Recovery of the western yellow-billed cuckoo would contribute to species richness and diversity and reduce the conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

**TARGET:** Improve riparian forest habitat in the Delta (◆◆).

**PROGRAMMATIC ACTIONS:** Improve and restore riparian forest habitat.

***RATIONALE:*** *Historically, the yellow-billed cuckoo commonly occurred from the Mexican border along the coast belt through the San Francisco Bay region as far as Sebastopol, Sonoma County, and through the Sacramento and San Joaquin Valleys. Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abut rivers, backwaters, or seeps. The cuckoo, is limited to some reaches of the Sacramento River, Sanborn Slough in the Butte Sink, and the Feather River. The population of this species is critically low.*

*Dense, large patches of willow-cottonwood riparian habitat are the preferred nesting habitat for this neotropical migrant. This habitat was once much more common, particularly along the Sacramento and San Joaquin Rivers; however, conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat. Other stressors that continue to adversely affect the species are loss of habitat as a result of bank protection projects, mortality associated with non-native nest parasites and predators, and inadvertent drift of some types of herbicides and pesticides into habitat areas.*

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